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THE CAPUT ULNAE SYNDROME IN RHEUMATOID ARTHRITIS

A study of the morphology, abnormal
anatomy and clinical picture

BY

MAGNUS BÄCKDAHL



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STOCKHOLM 1963

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A study of the morphology, abnormal
anatomy and clinical picture

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MAGNUS BÄCKDAHL

“For in rheumatoid arthritis one deformity leads
to another and early attention is essential.”

Vaughan-Jackson

STOCKHOLM 1963

Translated from the Swedish
by Patrick Hort

To the patients with rheumatoid arthritis whom it has been my good fortune to treat with surgery. They have all helped me to realise this work, not hesitating to undertake troublesome journeys and undergo tiring examinations; personifying, each and every one, the victory of the individual over his fate.

Almqvist & Wiksells

BOKTRYCKERI AKTIEBOLAG

UPPSALA 1963

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A study of the morphology, abnormal
anatomy and clinical picture

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INTRODUCTION

Interest in reconstructive surgery for rheumatoid hands has grown considerably in all parts of the world in recent years.

Experience shows that there is much to be gained in this field from surgery, which has hitherto been regarded as pointless or contra-indicated by the nature of the disease.

The change in attitude has brought together two specialities which were previously strangers—rheumatology and hand surgery.

The hand surgeon has a large new field to work in, a field that will no doubt expand rapidly. At the same time he is able and bound to study during surgery the abnormal anatomy “under the skin” in a quite new way.

Since the autumn of 1957 I have been collaborating as a hand surgeon with the rheumatological clinic at Karolinska Sjukhuset, Stockholm, and have undertaken about three hundred reconstructive operations on rheumatoid hands, all of them in consultation with my colleagues in rheumatology.

The main surgical problems in this new activity have led to repeated visits to Heinola, in Finland, where the cooperation between rheumatologist and surgeon started in 1952 and has since received world-wide recognition. My Finnish colleagues have placed their material at my disposal for this study. Twenty-one of the patients in the present material were treated at Heinola.

This study deals with the symptoms to be found in the wrist and hand in many cases of rheumatoid arthritis. I have coined the phrase “the caput ulnae syndrome” to serve as a blanket term for a number of functional and pathological changes, my justification being that these changes occur in the head of the ulna and in the ligamentary and tendon apparatus attached to this or in the neighbourhood.

Anatomic, pathological, roentgenologic and electromyographic studies have been made of the aetiology and changes in function for this syndrome; clinical examinations before and after the operation gave information on the results of surgical treatment as well as indications for the form this treatment should take.

1. NORMAL ANATOMY

ON THE ANATOMY OF THE CARPAL REGION

Before discussing the relevant changes in the joints of the carpal region something should be said about their detailed structure and function.

In the hand, palmar and dorsal flexion as well as ulnar and radial abduction occur at the radiocarpal and intercarpal joints. These movements centre on a transverse and a dorso-palmar axis, respectively, through the caput ossis capitati. Their range is about 170° and 60° respectively. In pronation and supination of the hand, the radius rotates on the proximal and distal radio-ulnar joints about the ulna, which serves as the fixed axis of the forearm. The axis for these movements runs through the centre of the heads of the radius and the ulna. The range of movement is about 155° (Fig. 1).

The articular surfaces in both the radio-carpal and the distal radio-ulnar joint permit a considerable range of movement. There is little skeletal support and it is the ligamentary and muscular apparatus that is largely responsible for maintaining the interrelation of the component parts.

The ligaments of the wrist may be divided into two groups: those for the radiocarpal and intercarpal joints and those for the distal radio-ulnar joint.

The ligaments between the radius and the carpus give the wrist dorsal as well as palmar and radial support. The dorsal apparatus is definitely weaker than the palmar (Figs. 2 and 3).

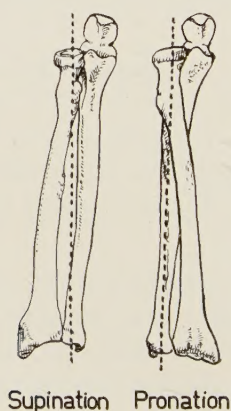


Fig. 1.

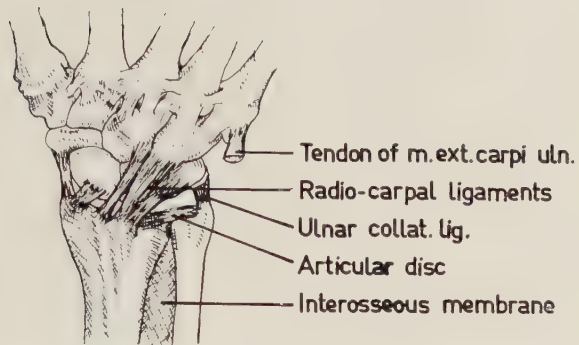


Fig. 2. Dorsal aspect of the distal radio-ulnar and the radiocarpal joints showing the ligaments.

The structures supporting the distal radio-ulnar joint are as follows:

- (a) The interosseous membrane of the forearm (Figs. 2 and 3), which extends down into the joint.
- (b) The articular disc (Figs. 2, 3 and 5), from the base of the styloid process and the neighbouring region of the carpal surface of the head of the ulna; this stretches across to the radius, where it attaches along the distal edge of incisura ulnaris radii. This ligament, which is partly converted into cartilaginous tissue, functions as a discus between the head of the ulna and the ulnar part of the carpus.
- (c) The ulnar collateral ligament (Fig. 2 and 5), which unites the head of the ulna with the ulnar part of the carpal skeleton.



Fig. 3. The ligaments at the distal radio-ulnar and the radiocarpal joints—palmar aspect.

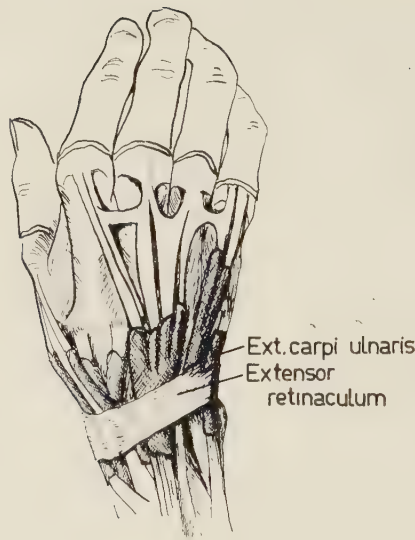


Fig. 4. The synovial sheaths of the extensor tendons at the back of the hand.

- (d) The articular capsule and the fibrous band that forms part of the tendon sheath across the wrist.
- (e) The extensor retinaculum (Fig. 4) and the flexor retinaculum form between them a support round the wrist.

The muscles involved in rotation of the forearm are of considerable importance for a correct interrelation of the radius and the ulna at the radio-ulnar joint and it appears that in this they are assisted by one of the extensors to the wrist.

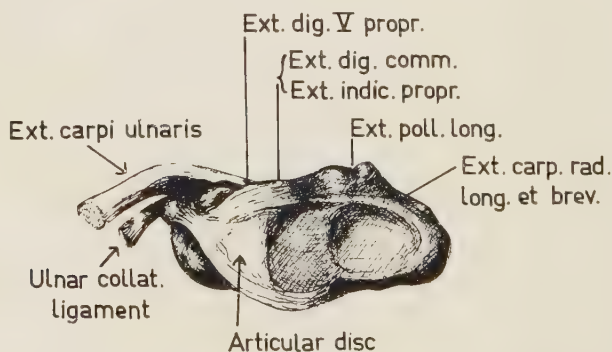


Fig. 5. The articular surfaces of the radius and the ulna at the wrist with the tendon of extensor carpi ulnaris and the ulnar collateral ligament. The sites of the compartments for the other extensor tendons are indicated.

The anatomy of this particular muscle—extensor carpi ulnaris—will be recapitulated here because changes in its function and course appear to be connected with dislocation of the head of the ulna in rheumatoid arthritis. This muscle arises from the lateral epicondyle of the humerus. It is innervated from the deep branch of the radial nerve. About three fingers from the head of the ulna it ends in a powerful tendon, which passes through a compartment formed by the extensor retinaculum above and fibrous tissues beneath and then continues to its insertion on the base of the fifth metacarpal. Where it passes the head of the ulna, the tendon, enclosed in a synovial sheath, runs in a groove with ulnar and palmar support from the styloid process (Figs. 4 and 5). The structure of the skeletal parts and, above all, the surrounding ligamentary tissues keep the tendon in place even during extreme pronation or supination of the wrist. These movements change the direction from which the tendon pulls on its insertion to such an extent that rotation must place a greater strain on this tendon compartment than on those of the other extensor tendons (see Figs. 13 and 14).

The tendon of extensor carpi ulnaris is the only extensor tendon that crosses the head of the ulna; hence it alone is greatly affected in its course by rotation of the forearm. The other extensor tendons to the wrist and the fingers run in tendon sheaths attached to the radius; their line of pull is therefore hardly affected by rotation movements in the wrist.

In current textbooks of anatomy, extensor carpi ulnaris is said to have the following function: to act in dorsi-flexion and in ulnar abduction at the wrist, in both cases in association with other muscles.

The muscle is also activated in abduction and extension of the thumb. A century ago, Duchenne noted its importance as a stabilizer when the hand is opened to grasp an object. Without this ulnar stabilization, the usefulness of the hand is considerably reduced.

DISTRIBUTION OF ACTIVITY IN MUSCLES ACTING ON THE WRIST¹

By M. BÄCKDAHL and S. CARLSÖÖ²

The purpose of this investigation was to ascertain the pattern of innervation for the muscles passing the wrist, during basic movements of this articulation. In the first place a study was made of whether the engagement of the muscles corresponded with their respective anatomico-mechanical requirements. Moreover, it was required to know whether any of these muscles is involved as an antagonist in governing or in stabilizing the movements. The action potentials were recorded in isotonic contraction during movement and in isometric contraction under load. The muscles examined were: the extensor carpi radialis and ulnaris, extensor digitorum communis, and the flexor carpi radialis and ulnaris, flexor digitorum superficialis and profundus. The study was limited to the basic movements of the wrist, namely dorsi-flexion, palmar flexion, and radial and ulnar abduction.

According to the standard textbooks of anatomy those movements take place about two perpendicular axes, both of which pass near the capitate bone, one of them in the radio-ulnar direction and the other in the dorso-volar direction. This means that all the flexors in question are mechanically capable of effecting volar flexion of the wrist, and all the extensors of effecting extension of it. According to Broman & Hjortsjö (1952) and Andreassen (1951) the extensor and flexor carpi radialis are mechanically capable of effecting radial abduction of the wrist. These authors assert that ulnar abduction is performed by the flexor and extensor carpi ulnaris.

Wachholder & Altenburger (1926) showed by electromyographic methods that there was a reciprocal innervation between these muscles during slow dorsi- and volar flexion.

Material

The investigation was performed on twenty-six subjects with ages ranging from nineteen to forty years. They were students, physicians and nurses, with clinically healthy joints and muscles, which functioned normally. At least two muscles were examined simultaneously on each subject.

¹ Reprinted from ACTA MORPHOLOGICA NEERLANDO-SCANDINAVICA, Vol. IV, No. 2, 1961.

² Received for publication Oct. 6, 1960.

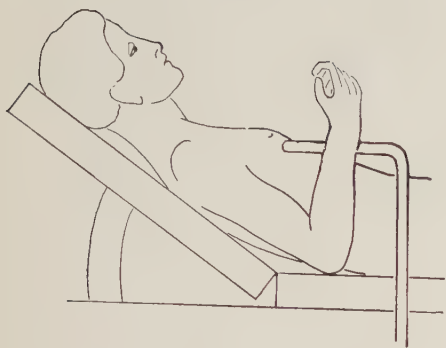


Fig. 6. Subject in supine posture.

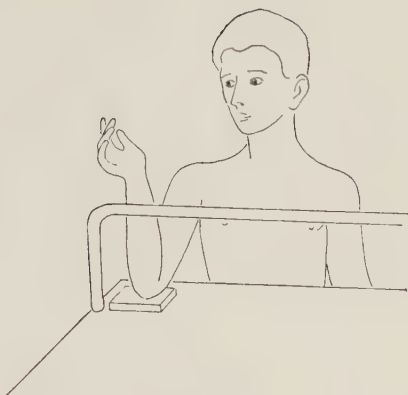


Fig. 7. Subject in erect sitting posture.

Method

Two types of electromyographic apparatus were used. One of them has been described in detail elsewhere (Carlsöö, 1956). The other was a Disa myograph. Except in two supplementary experiments co-axial needle electrodes were used. In all cases the recordings were made from the right arm. (All the patients were right-handed.) The subjects were placed in supine or erect sitting postures (Figs. 6 and 7). In both cases the right elbow rested on a firm support and the lower arm was supported either by one of the examiners or by means of a special construction. Prior to each experiment the subject was carefully instructed on the positions and movements under study, and was trained in them.

The activity was recorded first with the hand in the *rest position*—that is to say, in what the subject considered to be the most relaxed position. This also implied a check of the subject's general capacity for relaxing the muscles. In practically no case was any activity recorded in this position. After each recording of the potentials elicited by movement or by application of the load, a control was made in the rest position.

Each movement was begun from the *initial position*—that is, a position which enabled the subject to perform any of the pure basic movements. This initial position was not necessarily identical with the rest position, in which there was often a slight palmar flexion of the wrist, whereas the initial position was, as a rule, closer to the position of function; that is to say, with the wrist in slight dorsiflexion. In both these positions the fingers were as far as possible kept relaxed. In the initial position a low activity was recorded

in the extensors in a few cases. This activity served as a reference for the comparison of the activity elicited by different movements and positions. Every test was bracketed with this reference activity. If this was quantitatively equal at the beginning and the end of the test it was assumed that the recording conditions had remained unchanged. If not the E.M.G. was not used.

In the case of isometric contraction obtained by external loading, the hand was placed in the initial position. The load in these experiments varied between one and 10 kg and its line of action was in the plane of motion, but opposite in sense.

The movements, which were decided upon in advance and practised thoroughly by the subjects, were performed under the supervision of one of the investigators, who ensured that they were made slowly and uniformly and did not engage irrelevant muscles. The movements were continued to the respective extreme positions, the activity being recorded during the motion and when the extreme position had been reached.

Position of the electrodes

To ascertain the best position for the electrodes presented considerable difficulty. The needle electrodes of the type used have a pick-up range of 1–2 cm opposite the bevel (Wedell *et al.*, 1944). The muscles of the lower arm have a small cross-sectional area and are packed close to one another; they are usually in the form of thin plates, and in some cases it was therefore difficult to decide from the location of the needle which muscle was the source of the recorded potential. It was, moreover, possible that the electrode might be picking up potentials from two or more adjacent muscles. By means of anatomic landmarks, palpation and certain test movements during which the muscle activity was recorded, the placing of the electrodes could be checked.

The *extensor carpi radialis longus and brevis* were treated as a single muscle. The subject was required to perform repeated radial abduction, during which the muscle was located by palpation from the wrist proximally to about 10 cm distal of the elbow, where the needle was inserted 7–8 mm, perpendicular to the skin. By having the subject perform finger extension without moving the wrist it was possible to check that the needle tip was not too near the *extensor dig. communis*.

In the case of the *m. extensor dig. communis* there was no difficulty in placing the electrodes owing to its superficial position and accessibility for

palpation. They were located at the same level and depth as for the extensor carpi radialis. In some experiments the needles were placed centrally and in others they were placed peripherally in the radial and ulnar aspects.

The *m. extensor carpi ulnaris* was likewise easy to follow by palpation in voluntary contraction. There was, however, a risk that the electrode would approach too near the flexor carpi ulnaris, or the ulnar portion of the extensor dig. communis, and a check was therefore made of the position of the electrodes by recording the activity during finger extension with the wrist locked and during palmar and dorsi-flexion. In addition, the response on blocking the ulnar nerve was recorded.

There was no appreciable difficulty in placing the electrodes in the *flexor carpi ulnaris* and *radialis*. As in the above-mentioned muscles, they were inserted about 10 cm distal to the fold of the elbow.

The *m. flexor digitorum profundus* encloses the ulnar and proximal portions of the ulna. In this muscle the electrode was inserted at a point about 6 cm distally to the tip of the olecranon in the dorso-ulnar border. It was introduced until contact was made with the ulna and then it was withdrawn a few millimetres.

The *m. flexor dig. superficialis* presented the greatest difficulty because it is thin, covered by the palmaris longus, and situated close to the flexor carpi radialis, the underlying flexor dig. profundus and other muscles. The electrode was inserted into the palmar aspect of the middle lower arm to a depth of about one centimetre. The surface electrodes used for picking up potentials in these muscles consisted of two silver plates measuring 4×8 mm. They were placed just to the ulnar side of the flexor carpi radialis, about 10 cm proximally to the wrist. This test was performed on one subject who had no palmaris longus.

Results

In almost all the tests no activity was recorded in the initial position (Fig. 8). The results show that the innervation pattern during unresisted movements was the same as when the muscles were working isometrically against an external load.

In *palmar flexion* a marked rise was recorded consistently in the flexor carpi radialis and ulnaris and flexor dig. superficialis (Tables 1-3).

As regards the flexor dig. profundus two subjects consistently displayed a marked activity, and one gave only a small value. In two cases the muscle was passive in all tests (Table 4).

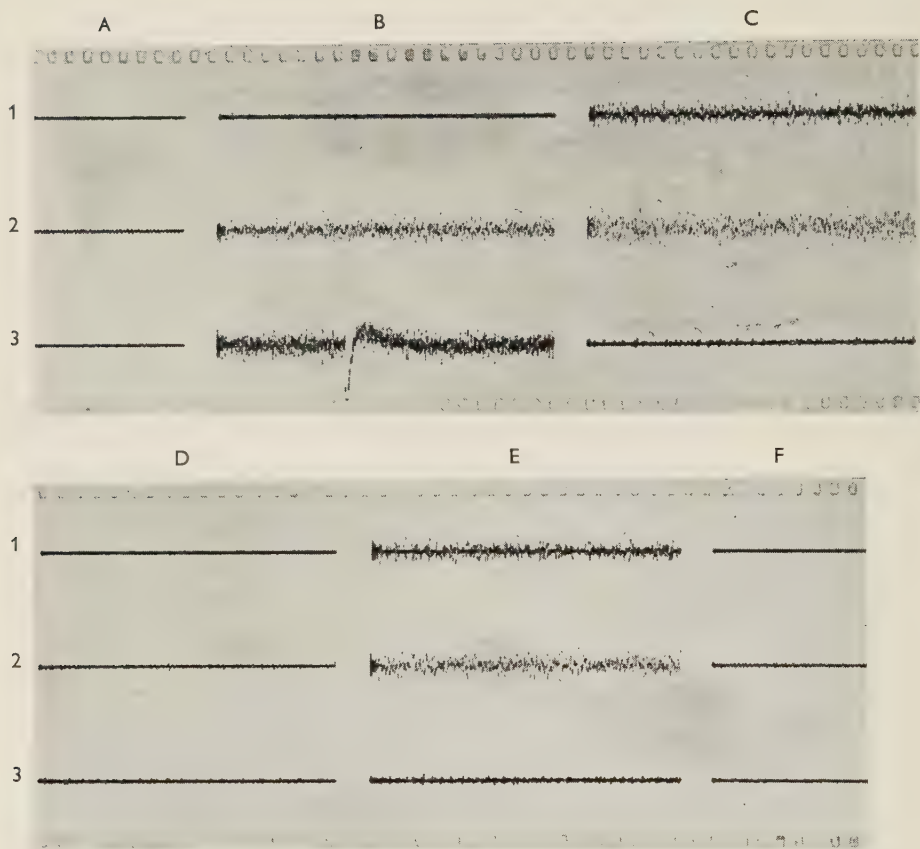


Fig. 8. E.M.G. 1: m. flexor carpi ulnaris. E.M.G. 2: m. extens. carpi ulnaris. E.M.G. 3: m. extensor dig. communis. Sections A and F: initial position. Section B: dorsi-flexion. Section C: palmar flexion. Section D: radial abduction. Section E: ulnar abduction.

From neither the extensor carpi radialis nor the extensor dig. communis (Tables 5 and 7) could activity be detected, both of them appearing to remain quite passive on palmar flexion.

From the extensor carpi ulnaris, on the other hand, a definite increase in activity was recorded in practically all the tests with this movement (Table 6).

Dorsi-flexion of the wrist always involved the extensor carpi radialis and ulnaris and the extensor dig. communis (Tables 5–7). All the flexors examined were quite silent except the dig. superficialis in two out of the seven subjects and the flexor digitorum profundus in one out of five subjects (Tables 4–7).

In *radial abduction* the extensor and flexor carpi radialis (Table 5) were

TABLE 1. *M. flexor carpi radialis.*

Movements	Subjects						
	S.B.	E.E.	Ö.E.	C.H.	H.N.	M.S.	P.Å.
Dorsi-flexion	—	—	—	—	—	—	—
Palmar flexion	+	+	+	+	+	+	+
Ulnar abduction	+	—	—	—	—	—	—
Radial abduction	+	+	+	+	+	+	+

+ indicates that definite action potentials were recorded in each test.

(+) indicates that action potentials, often less distinct, were recorded in a few tests.

— indicates that no potentials at all were recorded in the muscle.

TABLE 2. *M. flexor carpi ulnaris.*

Movements	Subjects					
	M.B.	E.E.	Ö.E.	L.L.	S.L.	H.N.
Dorsi-flexion	—	—	—	—	—	—
Palmar flexion	+	+	+	+	+	+
Ulnar abduction	+	+	+	+	+	+
Radial abduction	—	—	—	—	—	—

TABLE 3. *M. flexor digitorum superficialis.*

Movements	Subjects						
	E.M.A.	U.B.	Ö.E.	G.L.	B.M.	H.N.	L.R.
Dorsi-flexion	+	+	—	—	—	—	—
Palmar flexion	+	+	+	+	+	+	+
Ulnar abduction	—	+	+	—	—	+	—
Radial abduction	+	+	+	—	—	+	+

TABLE 4. *M. flexor digitorum profundus.*

Movements	Subjects				
	E.M.A.	U.B.	Ö.E.	G.L.	H.N.
Dorsi-flexion	—	+	—	—	—
Palmar flexion	—	+	+	—	—
Ulnar abduction	—	+	+	—	—
Radial abduction	—	+	—	—	—

TABLE 5. *M. extensor carpi radialis*.

Movements	Subjects						
	J.B.	E.E.	G.O.G.	K.L.	O.L.	D.N.	A.P.
Dorsi-flexion	+	+	+	+	+	+	+
Palmar flexion	-	-	-	-	-	-	-
Ulnar abduction	-	-	-	-	-	-	-
Radial abduction	+	+	+	+	+	+	+

TABLE 6. *M. extensor carpi ulnaris*.

Movements	Subjects										
	J.B.	M.B.	E.E.	K.L.	L.L.	S.L.	D.N.	A.P.	J.S.	T.T.	P.A.
Dorsi-flexion	+	+	+	+	+	+	+	+	+	-	+
Palmar flexion	(+)	+	+	+	(+)	+	+	+	+	+	(+)
Ulnar abduction	+	+	+	+	+	+	+	+	+	+	
Radial abduction	-	-	-	-	-	+	-	-	+	-	

TABLE 7. *M. extensor digitorum communis*.

Subjects	Movements			
	Dorsi-flexion	Palmar flexion	Ulnar abduction	Radial abduction
G.B.	+	-		
J.B.	+	-	-	-
S.B.	+	-	(+)	-
E.E.	+	-	-	+
G.O.C.	+	-	-	+
C.H.	+	-	-	-
E.L.	+	-	-	+
J.O.L.	+	-	-	+
K.L.	+	-	-	+
D.N.	+	-	+	+
A.P.	+	(+)	-	+
J.S.	+	-	-	-
M.S.	+	-	-	+
T.T.	+	-	(+)	+
P.Å.	+	-		

engaged in all cases. Action potentials were usually recruited also from the extensor dig. communis (Table 7). The flexor carpi ulnaris (Table 2) and, with two exceptions, the extensor carpi ulnaris (Table 6) were quite inactive. The flexor dig. superficialis gave a response in four cases and was silent in three (Table 3). The flexor dig. profundus was engaged in one out of five cases (Table 4).

Ulnar abduction showed activity of the extensor and flexor carpi ulnaris (Tables 6 and 2), but no response could be recorded from the flexor carpi radialis. The extensor dig. communis and the flexor carpi radialis were also passive in most subjects. In one series of tests (U.B.) the flexor dig. superficialis and profundus were engaged, as in radial abduction, and in the other cases the latter muscle remained inactive. In four out of the seven subjects potentials were recorded in the flexor dig. superficialis.

The study of the activity in *isometric contraction*, in which the muscles worked against, and counterbalanced, a force applied to the hand, showed a pattern of muscular involvement, that was essentially the same as those for the voluntary movements. When the load was increased from one to 10 kg there was a quantitative change in the activity but no appreciable variation in the pattern of co-ordination.

Discussion

In palmar flexion the flexor carpi radialis and ulnaris and the flexor dig. superficialis were engaged, from which it would seem that these three muscles work synchronously and that none of them acts as a prime-mover. The flexor dig. profundus, on the other hand, appeared not to contribute to the primary innervation pattern in palmar flexion, and hence is probably not essential to palmar flexion. For in only one of the five cases examined were action potentials recruited from this muscle during this movement, in spite of repeated tests on different occasions. This individual variation would appear to be ascribable to the fact that in persons with well developed co-ordination only the muscles belonging to the normal primary innervation pattern are engaged, whereas when the co-ordination is poorly developed the flexor dig. profundus is also involved. Wachholder and Altenburger showed that the extensor carpi radialis, which acts as an antagonist in palmar flexion, is passive when the movement is performed slowly. The present study confirmed this result and showed, moreover, that the extensor dig. communis is also passive, for from neither of these muscles were action potentials recruited even in extreme palmar flexion.

On the other hand, the extensor carpi ulnaris showed a more or less marked activity in all eleven cases. To ascertain whether potentials ascribed to this muscle actually originated in this muscle and not in the adjacent flexor carpi ulnaris, recordings were made after blocking the ulnar nerve at the level of the olecranon. There was no change in the activity in the portion of the muscle assumed to belong to the extensor carpi ulnaris in

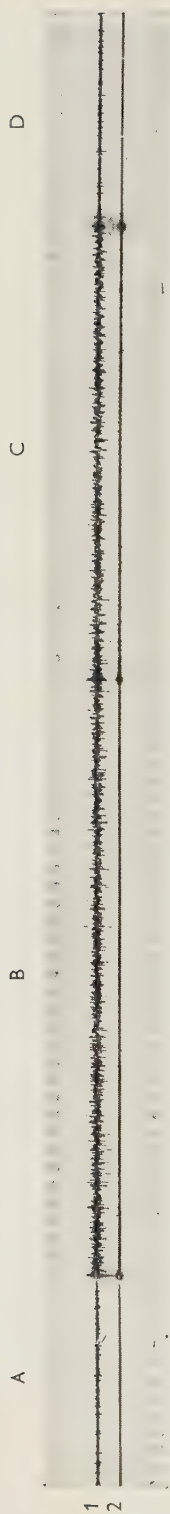


Fig. 9. E.M.G. 1: m. extens. carpi ulnaris. E.M.G. 2: m. flexor carpi ulnaris (ulnar nerve blocked). Sections A and D: the hand in the initial position. Section B: dorsi-flexion. Section C: palmar flexion.

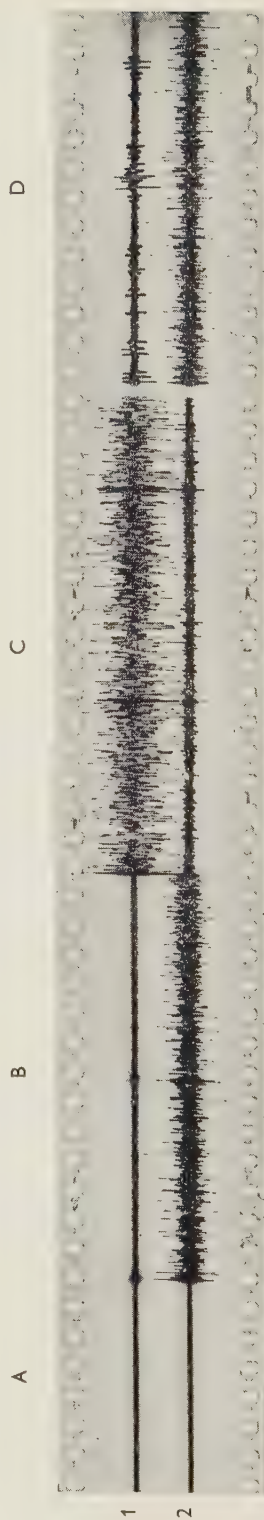


Fig. 10. A complementary test using surface electrodes. E.M.G. 1: flexor group of the forearm. E.M.G. 2: extensor group of the forearm. Section A: Initial position. Section B: voluntary max. dorsi-flexion of the wrist. Section C: voluntary max. palmar flexion. Section D: the subject standing on the hands.

these tests (Fig. 9). It would seem that this co-contraction of the extensor carpi ulnaris in extreme palmar flexion serves to stabilize the joint. Compared with the radial part of the joint the ulnar part has a less developed ligamentous and skeletal control. The muscle appears to belong to those engaged in the primary pattern of innervation that governs the palmar flexion of the wrist.

For *dorsi-flexion* the study seems to show that there is reciprocal innervation between the extensors and flexors. The examined extensors appear to work synchronously in dorsi-flexion and none of them seems to act as a prime-mover. Even in pronounced dorsi-flexion, as when standing on the hands, only a few potentials could be recruited from the flexors (Fig. 10). The limitation and stabilization of dorsi-flexion of the wrist thus appears to be performed by the ligamental and skeletal apparatus. In one case both the deep and the superficial finger-flexors displayed activity, but this subject (U.B.) had a poor general muscular co-ordination. To some extent this was also the case for one other subject (E.M.A.) (Table 3).

The form and arrangement of the bones of the wrist and the strength and distribution of the ligaments provide a better mechanical control of dorsi-flexion than of palmar flexion. This might explain why, in palmar flexion, there is also a muscular stabilizing and controlling mechanism in which the extensor carpi ulnaris seems to be responsible.

In *abduction movements* there seems to be a reciprocal innervation between the extensor and flexor carpi radialis, on the one hand, and the extensor and flexor carpi ulnaris on the other. This appears to be consistent with the mechanical properties of these muscles. Muscles such as the flexor dig. superficialis and profundus, whose lines of action intersect, or pass close to, the axis of motion in the abduction movements, were in some cases active and in others passive in both ulnar and radial abduction. The extensor dig. communis, on the other hand, was engaged in radial abduction in most of the subjects but only in one case in ulnar abduction. Simultaneous recordings from the ulnar and radial portions of this muscle revealed no difference in the action potentials. This suggests that the muscle is engaged as a unit and not as portions. In abduction movements there thus appears to be a primary, consistent innervation pattern with distinct agonists and antagonists, according to the principle of reciprocal innervation, and the passive parts of the movement apparatus constitute an essential factor in the control and limitation of the movement. In this innervation pattern, however, there are individual variations with some subjects engaging muscles besides those primarily responsible for performing the basic movements, for example finger muscles passing the wrist.

SUMMARY

The purpose of this investigation was to ascertain the pattern of innervation for the muscles passing the wrist, during basic movements of this articulation.

A fairly close correspondence was found between the mechanical properties and physiologic function of the muscles, except in the case of the extensor carpi ulnaris, which was engaged in both dorsi-flexion and palmar flexion. Even in ordinary movements there is a certain individual variation in the innervation pattern.

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ADDITIONAL ELECTROMYOGRAPHIC STUDY

As a supplementary study, the activity in extensor carpi ulnaris during extension of the thumb was examined electromyographically in five subjects with healthy wrists. In every case considerable activity was recorded when the subject extended and abducted the thumb.

Fig. 11 shows the pattern of innervation for extensor carpi ulnaris as recorded electromyographically for various movements at the wrist and during extension of the thumb.

STEREOROENTGENOGRAPHIC STUDY OF THE TENDON OF EXTENSOR CARPI ULNARIS

At surgery of the wrist in patients with rheumatoid arthritis I have noticed that in many cases the course of the tendon differs considerably from the normal one described in current textbooks of anatomy.

This discrepancy has led me to search for a method by which the course of this tendon could be analysed in these patients and in a normal material.

Material and method

The normal material comprised five persons (age range 22 to 36 years) with clinically healthy wrists.

The subject sat on a chair with the arm held forward and the forearm

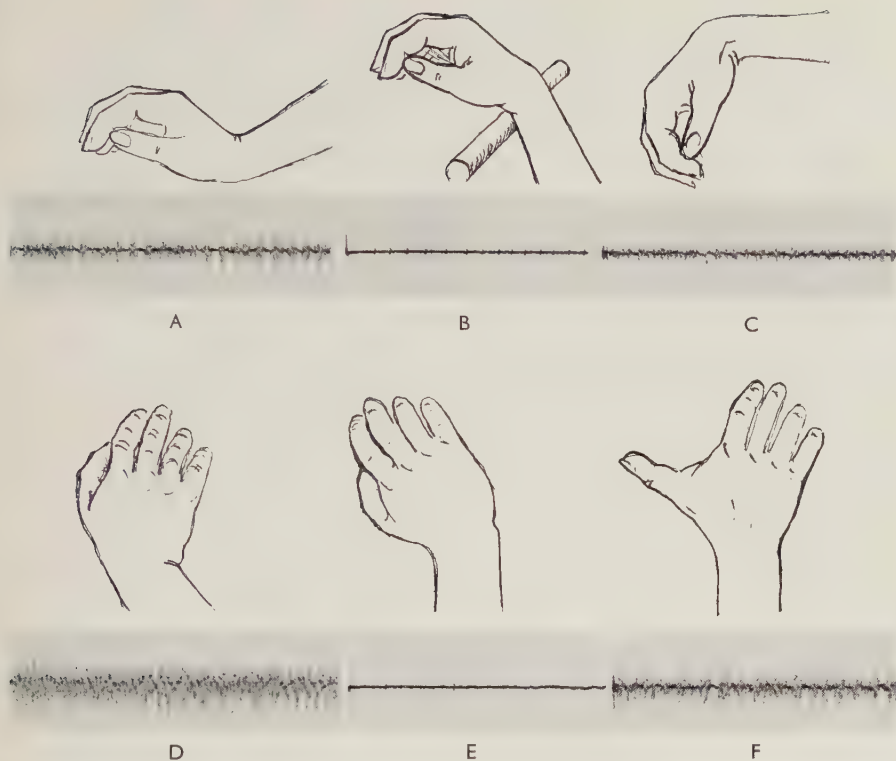


Fig. 11. The activity in extensor carpi ulnaris recorded in normal cases at: A. Dorsi-flexion. B. Initial position. C. Palmar flexion. D. Ulnar abduction. E. Radial abduction. F. Extension of the thumb.

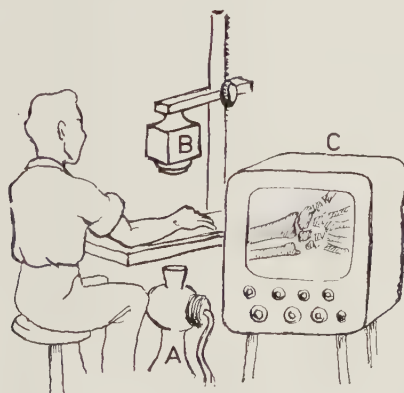


Fig. 12. A. Roentgen tube.
B. Camera and amplifier.
C. Television screen.

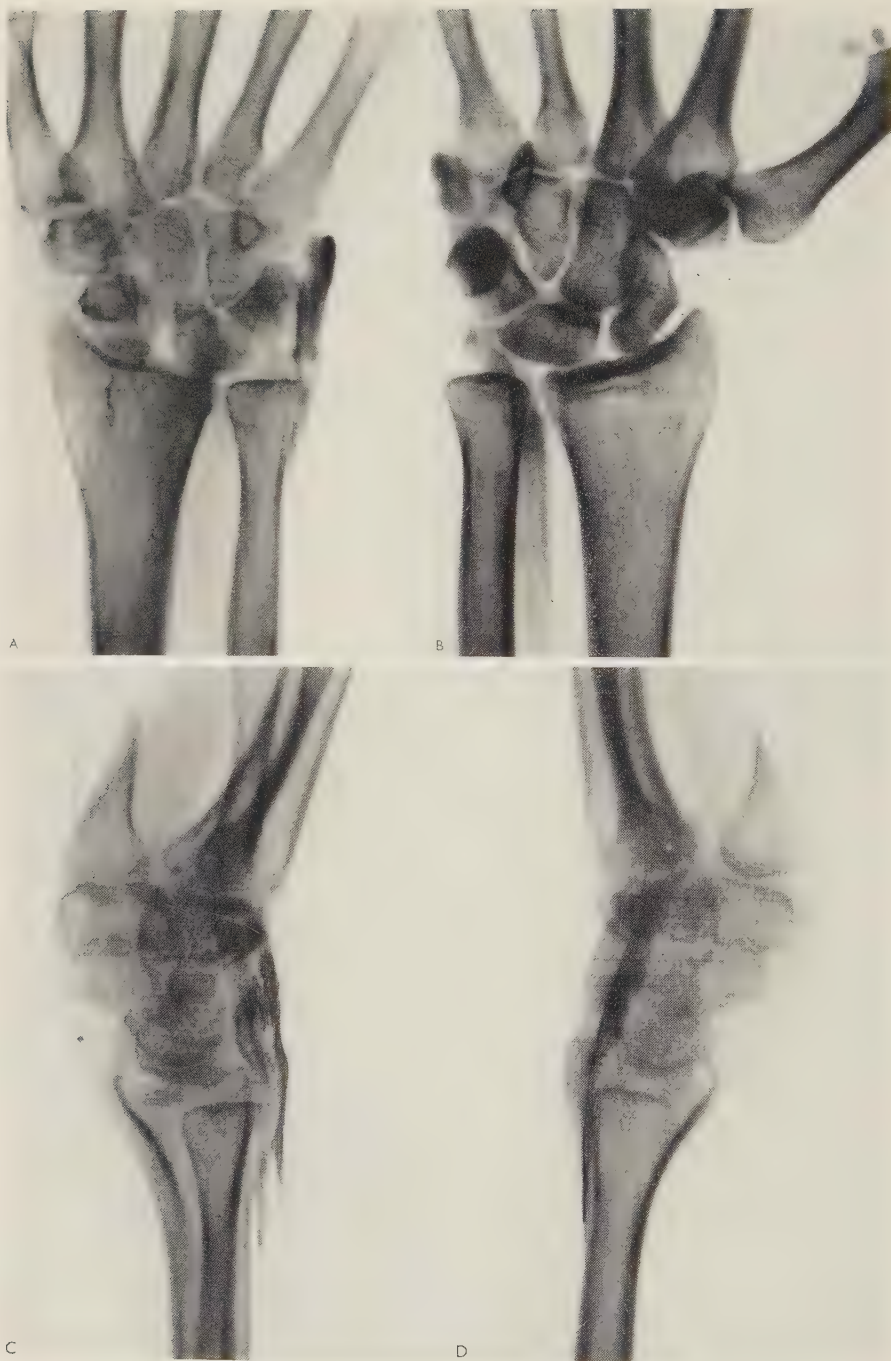


Fig. 13. Stereoroentgenograms are difficult to reproduce and clearly cannot be instructive when they are not viewed in pairs three-dimensionally. The present sequence shows, however, that the tendon is clearly recognisable after injection of contrast into its sheath. The position of the hand and the projection are illustrated in the accompanying reproduction of a hand skeleton.



Fig. 14. Skeleton of wrist and hand with a mock extensor carpi ulnaris and intrinsic ligaments attached.

- | | |
|-------------------|---|
| A. Pronate hand. | C. Side view of slightly supinate hand. |
| B. Supinate hand. | D. Side view of pronate hand. |

-
- A. Pronate hand, dorso-palmar projection.
 B. Supinate hand, palmar-dorsal projection.
 C. The hand in a position between pronation and supination, radio-ulnar projection.
 D. Pronate hand, ulnar-radial projection.

resting on a roentgen table with the palm downwards. The hand and wrist were placed so that they could be irradiated and a picture obtained on a TV screen nearby (Fig. 12). From this position the subject performed slight ulnar abduction and supination, so that the tendon of extensor carpi ulnaris could be palpated quite easily where it crossed the head of the ulna. After the skin had been cleansed, a thin cannula attached to an injection syringe was introduced into the tendon at the level of or just proximal to the head of the ulna. The syringe was then detached from the cannula and the subject performed slight abduction movements: the cannula moved distinctly if its tip was in fact in the tendon. The syringe was reattached to the cannula and contrast was carefully injected. The pressure of the contrast medium forced the tip of the cannula out of the tendon into the space between this and the synovial sheath. The dispersion of the contrast medium was followed on the TV screen during the injection.

Urografin was the contrast used, at first in 40% solution but subsequently in 60%, both for these subjects and for the rheumatoid patients examined in this way. As a rule, the tendon sheath filled up quickly and uniformly over the area in question, though in some cases an even better distribution was obtained if the subject performed slight abduction movements.

As soon as a satisfactory distribution of contrast had been noted on the TV screen, the subject was transferred without delay to a nearby roentgen table for stereoroentgenography. The following programme was adhered to throughout:

Frontal projections. (a) The subject holds the hand pronate on the table. Dorso-palmar irradiation.

(b) The palm of the hand is held upwards in extreme pronation with the hand fully open. To achieve this position the subject has to lean forward and rotate the arm inwards and backwards at the shoulder. Palmar-dorsal irradiation.

(c) The subject sits with the elbow joint flexed and the wrist fully supinated so that the back of the hand rests on the table. Palmar-dorsal irradiation.

Lateral projections. (a) The wrist is moderately supinated, the elbow joint flexed and the hand rests on its ulnar edge. Radio-ulnar irradiation.

(b) The hand is considerably pronated with the ulnar edge uppermost. Ulnar-radial irradiation.

Results

The contrast medium did not give rise to complications in the form of pain during the examination, or subsequent discomfort. The contrast was

resorbed so fast that in many cases it gave a noticeably fainter picture at the end of the stereoroentgenography than at the beginning.

As seen in the viewer, the stereoscopic pictures provided clear information as to the course of the tendon. Changes in the direction of pull of the tendon from the head of the ulna to its insertion on the fifth metacarpal could be followed for the different degrees of rotation.

The series of pictures showed that in all the normal cases examined, the tendon's location in its skeletal groove on the head of the ulna remained unchanged. Not even maximum rotation movements resulted in any visible lateral displacement.

SUMMARY AND DISCUSSION

The considerable mobility at the wrist allows the hand to function efficiently in a great many different positions. "The position of function"—with the hand halfway between pronation and supination, the wrist in about 20° of dorsiflexion and 10° of ulnar flexion—is a term coined by Bunnell to indicate the most effective position as regards strength of grip, but clearly there are many tasks for which another "position of function" is adopted. Consequently, the activity in the muscles that stabilize the wrist must vary according to the task being performed.

In the electromyographic study it was found that the pattern of innervation for the muscles acting on the wrist corresponded on the whole to the potential mechanical function of these muscles. *A notable exception, however, was extensor carpi ulnaris, which was the only one of the extensors at the wrist in which activity could be demonstrated at palmar flexion.* It would seem that this muscle helps to stabilize the ulnar part of the joint at palmar flexion, as the skeletal and ligamentous support in this region is weak.

During rotation at the wrist the tendon of extensor carpi ulnaris changes the direction of its pull on its insertion. A study in healthy wrists, by means of stereoroentgenography after the injection of a contrast medium into the synovial tendon sheath, showed that the tendon compartment prevented lateral displacement of the tendon from its groove on the head of the ulna even at extreme pronation or supination.

The anchorage of this tendon on the head of the ulna is of importance to the relation between the head of the ulna and its articulation with the radius. This will be discussed in connection with the pathological anatomy (see p. 46).

2. THE CAPUT ULNAE SYNDROME



Fig. 15. "This is a clear-cut, clinical picture of a lesion that can be repaired."

VAUGHAN-JACKSON

DEFINITION

Rheumatoid arthritis attacks all joints in the body in the same way as regards the pathological changes involved. The consequences of the destructive processes vary, however, according to the structure and function of the joint.

In the case of the wrist and hand in rheumatic individuals, there is a typical picture connected with the changes in the distal radio-ulnar joint. They may result in the development of a combination of symptoms to which I shall be referring as the caput ulnae syndrome.

A number of the changes which characterize this syndrome have already

been described by other authors, whose names are associated with observations and descriptions of, for instance, the mechanism for the tendon ruptures that sometimes occur.

My own investigations have taken into account both these and other aspects of what happens in this region of the wrist in rheumatoid arthritis. It is this picture, with the discoveries and studies of previous authors as its central perspective, that I wish to name the *caput ulnae* syndrome in rheumatoid arthritis.

Clinically, the syndrome presents as follows:

- (a) The patient complains of increasing weakness in the wrist with pain on movement, especially during rotation, and frequently considerable reduction in the range of rotation.
- (b) The *caput ulnae* forms a prominent lump on the dorsal aspect of the wrist and is capable of abnormal dorso-palmar displacement in relation to its articulation with the radius ("piano-key symptom") often with painful crepitations when the examiner tests this.
- (c) There is a soft, fluctuating swelling on the ulnar aspect of the wrist and back of the hand, with the extensor retinaculum forming a depression across it.
- (d) In some cases this picture is complicated by dropping of one or several of the ulnar fingers due to rupture of the long extensors where they pass the head of the ulna. This is an ultimate complication of the syndrome and need by no means be present.

A painful, insufficient wrist together with an inability to extend one or several of the fingers reduces the function of the hand considerably, especially when the hand has to be opened to grasp an object.

INCIDENCE

There is little chance at present of establishing the incidence of this syndrome. How many develop an advanced *caput ulnae* syndrome cannot be calculated nor the true frequency of tendon rupture as a complication.

Over eleven hundred surgical interventions upon the wrist and hand have been performed at Heinola; in 380 the syndrome indicated resection of the head of the ulna and a synovectomy; 21 of these also had tendon rupture at the head of the ulna.

In the K.S. material, which comprised 298 operations—nearly all of them

on the wrist and hand—there were 44 resections of the head of the ulna for various degrees of the caput ulnae syndrome; seventeen of these had tendon rupture as their ultimate complication.

These figures, as well as those reported by other authors show only how many patients have had the diagnosis established, with surgical treatment as a result. There must be many more which have never been operated on.

3. PATHOLOGICAL ANATOMY IN THE CAPUT ULNAE SYNDROME

PREVIOUS EXAMINATIONS

The clinical symptoms weakness in the wrist and hand, reduced mobility and pain on movement at the wrist, and dorsal prominence of the caput ulnae are each of them described in current textbooks on rheumatoid arthritis, which also contain descriptions and illustrations by a number of authors of the typical roentgenological changes in the distal radio-ulnar articulation.

Tendon rupture associated with rheumatoid arthritis has been reported by many authors. Rupture of the tendon of extensor pollicis longus has been described by von Stapelmohr (1940), Wadstein (1946), Harris (1951), and Mathieu-Pierre-Weil and Canet (1952). In histological investigations of the ruptured tendon some of these authors demonstrated degenerative changes.

The first description of tendon ruptures as a complication of the caput ulnae syndrome came from Vaughan-Jackson (1948), who reported ruptures of the extensor tendons to the fingers over the caput ulnae in two cases of arthritis in the distal radio-ulnar joint. (That these were cases of rheumatoid arthritis was in fact only confirmed in a later report.) He was the first to describe the way in which these ruptures come about. Both cases had dorsal dislocation and changes in the skeletal structure of the caput ulnae, which had been transformed into something like a saw. Partly as a result of the dislocation, the caput ulnae pressed on and perforated the tendon sheaths to the ulnar finger extensors, which were "sawn" through during rotation movements at the wrist.

A series of five cases of tendon ruptures (Laine & Vainio, 1955) included one case where the long extensor tendons to the fingers via the caput ulnae were affected. In this case the tendon stump was examined for histological changes and a rheumatoid granuloma was found. In an extensive clinicopathological study of tendon lesions in rheumatoid arthritis, Kellgren & Ball (1950) reported the results of histologic examination of 38 biopsies of the flexor tendons and 15 of the tendon sheaths. These were compared with corresponding biopsies from five cases of Quervain's disease. In their material

they found tendon lesions in approximately half the cases of rheumatoid arthritis. The histologic picture of the tendons in these differed from those in the cases of Quervain's disease.

In a series of five cases (Straub & Wilson, 1956) the causes of tendon rupture were considered to be:

1. Attritional change in the tendon as a result of rheumatoid synovitis.
2. Attrition due to age.
3. Increased mechanical wear and tear due to the prominence of the distal end of the ulna.

Another four cases of these ruptures have been reported with anamnestic data but without any discussion of the causes (Brewerton, 1957).

In 1958 Vaughan-Jackson published a second report of thirty cases and in 1962 his material comprised thirty-five cases.

A further material of sixteen cases of tendon rupture as a complication of the caput ulnae syndrome was presented by Pulkki & Vainio in 1962. This material, which now comprises twenty-one cases, has been placed at my disposal for examination and is included in the present work.

Another aspect of the abnormal anatomy in the distal radio-ulnar joint has been studied by Ehrlich *et al.* (1959). The course of dislocation of the caput ulnae was studied in six cases at surgery and by histological examination of resection specimens from the distal end of the ulna and its ligament. The articular disc had been totally destroyed in five cases, while only remains of this structure were found in the sixth. These authors considered that the destruction of this disc is the most important factor leading to dislocation of the distal end of the ulna from its articular surface on the radius—a dislocation that contributes to rupture of the extensor tendons which cross this region.

These authors, as well as Vaughan-Jackson and Straub & Wilson, report that at surgery the extensor retinaculum was found to have undergone no extensive changes. They noted that the synovitis had destroyed the intrinsic ligamentary apparatus but not the superficial. Consequently, it was considered that the extensor retinaculum contributed to ruptures by acting as a resistance to the head of the ulna.

OWN STUDIES

Observations at surgery

In a personal series of forty-four cases presenting varying degrees of the caput ulnae syndrome in rheumatoid arthritis—seventeen with tendon rup-

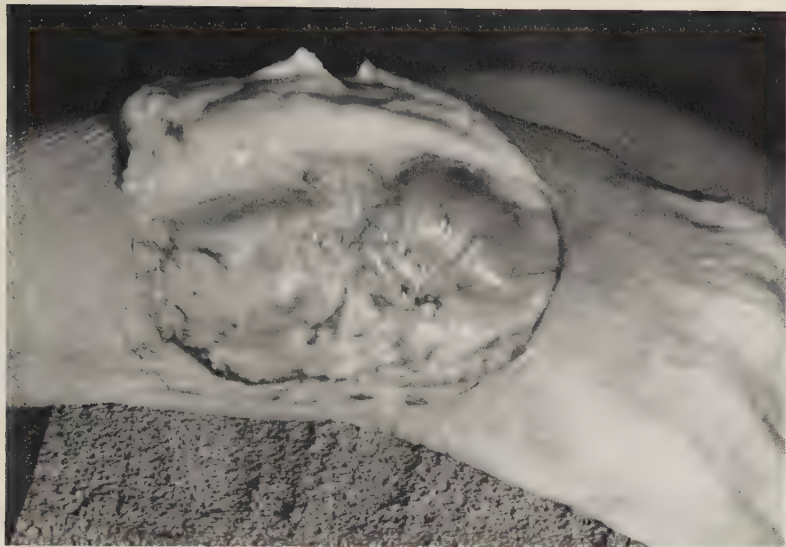
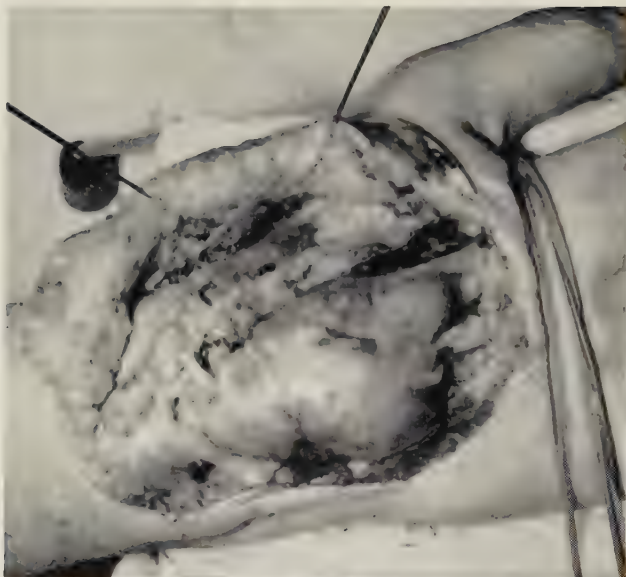


Fig. 16. The fibrous strands of the extensor retinaculum are stretched and thin but not broken and form a collar round the bulging synovial compartments at the level of the wrist.

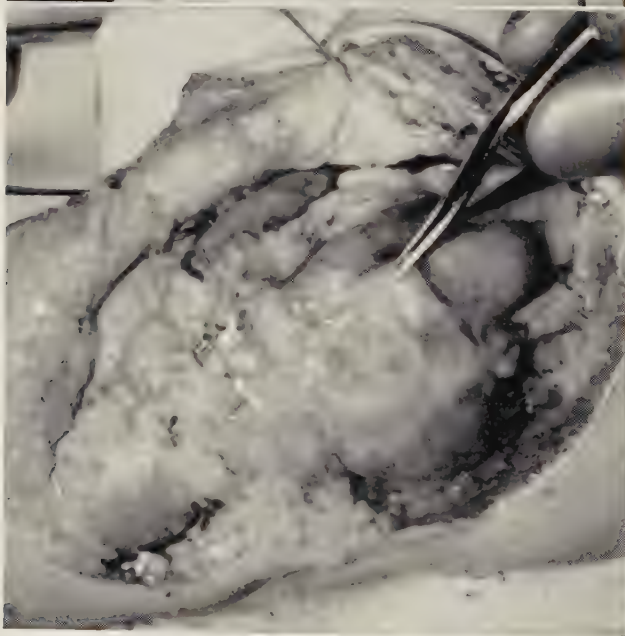
ture—I have found the following picture upon surgical exposure of the distal radio-ulnar joint:

The extensor retinaculum is stretched and thin, with its fibrous strands separated from each other but not broken individually. The synovial sheaths of the extensor tendons are swollen and have in many cases fused to form a bulging sack both proximal and distal of the extensor retinaculum, which forms a collar round the synovial compartments at the level of the wrist (Fig. 16). The synovial bursae contain an exudate that is sometimes gelatinous, sometimes like porridge (Figs. 17 and 18). The extensor tendons enclosed in these bursae often present lumpy prominences and are surrounded by brownish, discoloured synovial tissue.

In cases with tendon rupture the stumps of the tendons are macroscopically degenerate with a dull “lifeless” surface. Sometimes the proximal and distal stumps are jointed by a thin strand of tissue which is clearly not tendinous (Figs. 19 and 20). The tendon of extensor carpi ulnaris is often enclosed in a synovial fur as far as to its point of insertion. The tendon is dislocated from its normal position on the caput ulnae and is abnormally free from this. Dissection in this region showed that its tendon compartment had been entirely destroyed (Fig. 21).



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Fig. 17-18. The synovial sheaths for the extensor tendons have merged to form a bulging thickwalled sack containing a partly gelatinous, partly porridge-like substance.



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Fig. 19. Rupture of the extensor tendons. The tendon stumps widely separated. The caput ulnae has been resected.

Fig. 20. The extensor tendons for dig. V-IV and III have ruptured but the stumps are held together by fibrous tissue. The distal stumps of the tendons for the ring and little fingers display nodulous swellings.

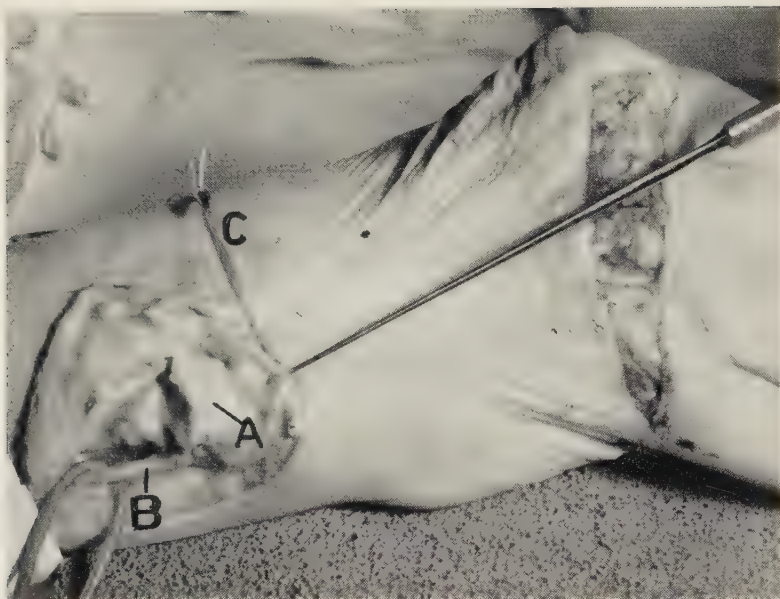


Fig. 21. The picture at surgery for the caput ulnae syndrome with a risk of tendon rupture.

- A. The dislocated and much-altered head of the ulna with its sawlike edge.
- B. The tendon of extensor carpi ulnaris, dislocated in a palmar direction.
- C. Thread retracting the dorsal branch of the ulnar nerve. (This operation included corrective surgery at the metacarpo-phalangeal joints.)

In two cases (one from Heinola and one from K.S.) the tendon was found to be so degenerate macroscopically that it could not be used in repair of the hand. The tendon had degenerated distal of the head of the ulna.

In every case with rupture of the finger extensors, the head of the ulna was found to have considerable changes in its skeletal structure (see page 40). In some cases a perforation was located in the floor of the compartment for the tendons of the long extensors to the fingers; this hole was the result of attrition by the head of the ulna during rotation movements at the wrist (previously described by Vaughan-Jackson).

The articular disc, which holds the head of the ulna and the radius together, had disappeared apart from a few remains of ligamentary tissue around the styloid process on the ulna (see p. 38).

The ulnar collateral ligament had also disappeared in every case.

Histologic examination

Specimens for histologic examination were taken in most of the cases in both the Heinola and the K.S. material. Two types of specimen were taken:

tendinous tissue and the resected portion of the head of the ulna with the attached remains of ligaments.

In the Heinola material the specimens all consisted of ruptured tendon stumps with some of the surrounding synovial tissue. In a number of cases the original slides have been placed at my disposal and I have had access to the report of the Finnish pathologist in eighteen cases. In the K.S. material too, the stumps of the ruptured tendons were examined as were, in some cases, biopsies from adjacent non-ruptured tendons. The tissues were fixed in 10 per cent formalin solution, embedded and sectioned in the ordinary way and stained with van Gieson's method and haemotoxylin-eosin.

Ruptured tendons

The most impressive changes were found in the tendon sheath, which showed varying degrees of chronic synovitis of rheumatoid type, and in the interstitial connective tissue in the tendon itself, i.e. the peritenoneum and mesotenoneum. The peritenoneum-mesotenoneum was often much increased and the site of a lively formation of granulation tissue with a varying amount of infiltration of lymphocytes and plasma cells. Foam cells and iron pigment were often present. In many cases this granulation tissue showed fibrinoid degeneration and necrosis, occasionally with a palisade-like arrangement of the surrounding fibroblasts. On the other hand, there were no typical rheumatoid nodules or Aschoff bodies. The cellular granulation tissue in places changed into fibrous tissue, partly young and vascular, partly highly sclerotic. No significant vascular changes were noted, though small arteries sometimes showed uncharacteristic hypertrophy of the media with some obliteration of the lumen.

In all cases of rupture the tendon tissue itself presented degenerative changes. These consisted of separation, disintegration and fragmentation of the collagen bundles; sometimes the collagen bundles were swollen and confluent, forming structureless areas without stainable cell nuclei. Sparse inflammatory cellular infiltration or streaky granulation tissue was often seen. In one or two cases the tendon tissue had been partly replaced by undifferentiated and apparently newly-formed connective tissue. Minor deposits of calcium were observed in one case. Many cases clearly showed fibrinoid degeneration and necrosis in the tendon tissue itself but without inflammatory reaction or signs of nodulous formation.

Bone fragments were not found in the tendon or the surrounding tissues in any of the cases.

The specimens from adjacent tendons that had not ruptured showed no convincing degeneration of the tendinous tissue itself. There was, however,

pronounced proliferation and chronic inflammation in the peritenoneum to the same extent as in the ruptured tendons.

Resected head of the ulna

In the K.S. material great care was taken at surgery when exposing and resecting the head of the ulna in order to avoid trauma of the ligamentary structures. As soon as the operation had been completed, the surgeon (myself) cut off the distal part of the specimen. A vibrating saw was used in order to protect the soft tissues. This distal part of the specimen was then decalcified in formic acid, sectioned and stained with van Gieson's stain and haematoxylin-eosin.

Specimens from thirteen cases were treated in this way and examined histologically. In one case (case 31) a loose piece of tissue was also examined histologically; it was judged by the surgeon to have emanated from the articular disc. Every case presented changes characteristic of rheumatoid arthritis, i.e. atrophy of the bone, destruction of the articular cartilage, pannus formation, chronic synovitis with infiltration of lymphocytes and plasma cells and fibrinoid degeneration in both synovia and pannus. In about half the cases it was not possible to distinguish any remains of the articular disc with certainty from the thicker parts of the pannus or from frayed parts of the joint capsule. In the other cases remains of the attachment of the articular disc were seen, consisting of a fringe of hyalinized, acellular connective tissue, often with fibrinoid degeneration and ingrowth of granulation tissue. No remains of cartilaginous tissue were found in any of the cases.

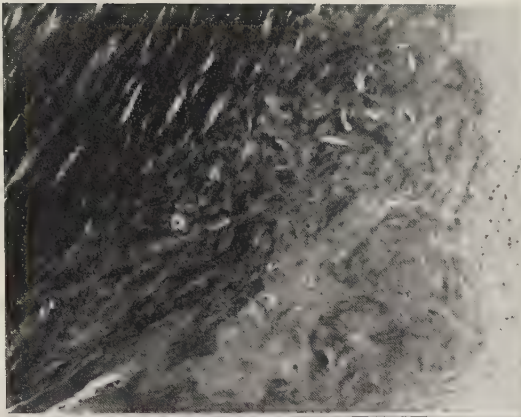
The free piece of tissue from Case 31 was found to be differentiated connective tissue, of a fascia-like or tendinous structure. In parts the tissue was well preserved, in others it was completely necrotic. It was embedded in granulation tissue with a wealth of foam cells and iron pigment. The picture was thus reminiscent of pigmented nodular synovitis. No cartilaginous structures were observed.

Discussion

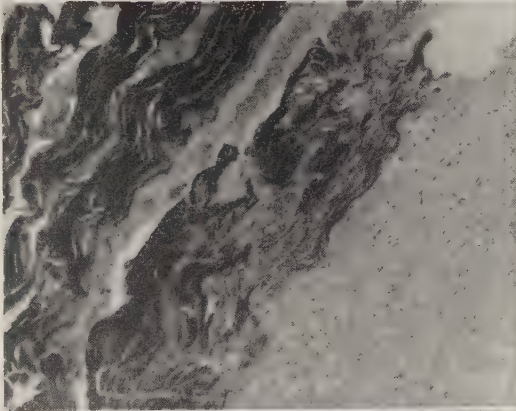
Since in general there was a long interval between the rupture and the operation, there is little chance of determining to what extent the changes

Fig. 22. Section from tendon near the point of rupture. Upper left, relatively normal tendon tissue. In the middle, advanced degeneration of tendon tissue with separation and disintegration of the collagen bundles. Bottom right, necrotic fibres and sparse inflammatory cell infiltration. van Gieson.

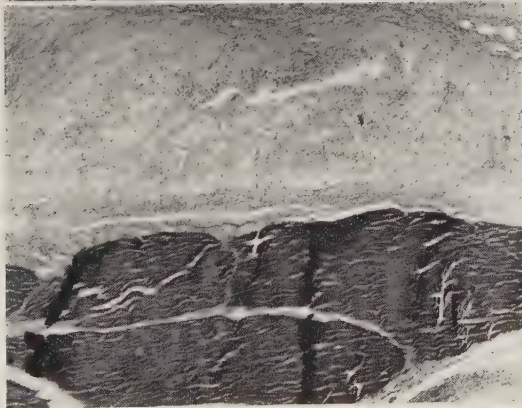
Fig. 23. Section from ruptured tendon stump. Left, degenerate tendon tissue with small areas with frayed and separated collagen bundles and necrotic fibres. Bottom right, formation of granulation tissue in the peritenoneum. van Gieson.



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Fig. 24. Section from a non-ruptured extensor tendon. Below, histologically normal tendon tissue. Above, the peritenoneum with pronounced proliferation of granulation tissue and inflammatory cell infiltration. In the middle, necrotic fibres and signs of a palisade-like arrangement of surrounding fibroblasts. van Gieson.

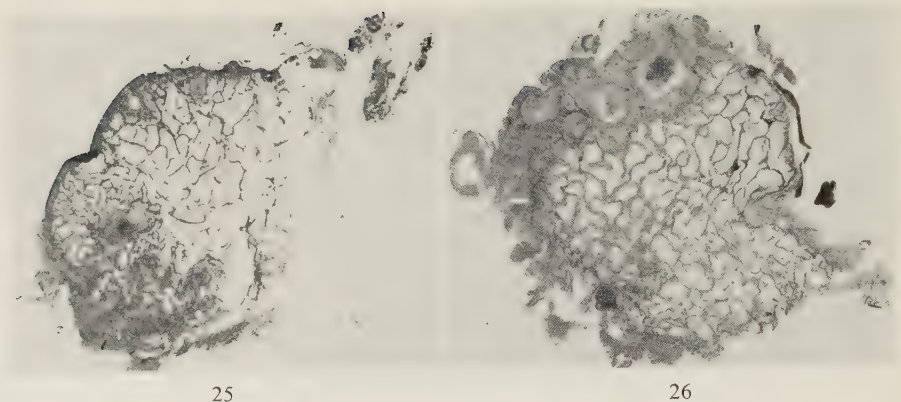


Fig. 25-26. Distal end of the head of the ulna with remains of the ligamentary attachments. For details see text.

in the tendons were present before the rupture. The histologic picture in tendon rupture in non-rheumatoid patients differs, however, from the one described here in several respects, indicating that the changes in the present material may partly be a result of the rheumatic disease. Examination of tendon rupture in non-rheumatoid patients—principally the Achilles tendon, but also the tendons of quadriceps femoris and extensor pollicis longus—has not revealed fibrinoid degeneration in the tendon tissue, whether the operation took place a few hours or several weeks after the rupture. Regeneration after rupture in non-rheumatoid patients also presents a different picture. The granulation tissue is all of the same age, successively maturing into undifferentiated connective tissue that gradually takes on the appearance of tendinous tissue. There is no fibrinoid degeneration in the granulation tissue either (Orell, 1958; Arner, Lindholm & Orell, 1959). Kellgren & Ball (1950) have published an extensive study of unruptured flexor tendons in rheumatoid hands. In early cases changes were found mainly in the peritenoneum and the mesotenoneum, where a lively formation of granulation tissue was seen. In more advanced cases these authors also found degeneration and fibrinoid necrosis in the tendon tissue itself. In principle, therefore, the unruptured flexor tendons presented the same changes as those reported here for the ruptured extensor tendons.

There are thus several indications that the histologic changes in the ruptured tendons are largely an expression of the rheumatoid disease and not simply secondary to the rupture. The degeneration in the tendon tissue may perhaps be due in part to impaired nutrition as a result of the chronic proliferative inflammation in the interstitial connective tissue in the tendon.



Fig. 27. Routine roentgenogram of the wrist showing typical changes in the distal radio-ulnar joint. A year later this patient had rupture of the long extensors to dig. V and IV.

The histologic examination of the resection specimens from the head of the ulna confirm the macroscopic observation that the ligaments which have attachments in this region are completely destroyed.

Routine roentgenograms

A study was made of the roentgenograms of the wrist and hand taken as a matter of routine. These roentgenograms had been taken with the patient seated at the roentgen table and the palm of the hand resting on the film cassette. The wrist was thus held pronated and irradiation was from the dorso-palmar aspect. In both the Heinola and the K.S. material roentgenograms were in many cases taken at different stages in the course of the disease and these could be compared with one another.

In addition to the typical more general roentgenological changes found in rheumatoid arthritis—decalcification, narrow joint cavities and possibly fusion of the carpals—these cases presented typical changes in the distal radio-ulnar joint. The rounded structure of the head of the ulna is transformed into a jagged, in some cases chisel-like formation. The styloid process changes its structure and may even have disappeared completely. The



Fig. 2° Drawings of 24 routine roentgenograms taken not more than a year before or after tendon rupture. The shaded regions denote pronounced erosion.

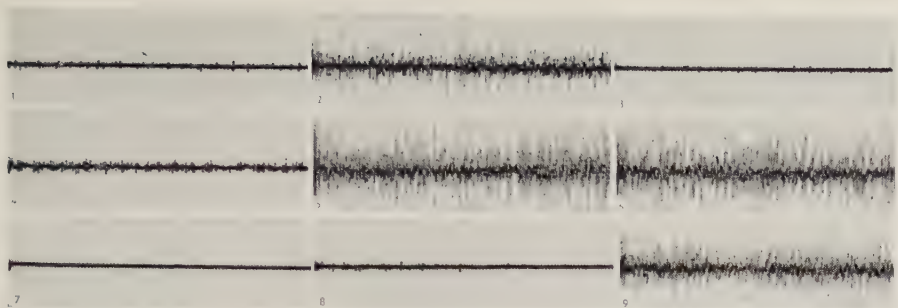


Fig. 29. The activity in m. extensor carpi ulnaris recorded in a patient with pronounced caput ulnae syndrome in rheumatoid arthritis.

Section 1. initial position. Section 2. dorsi-flexion. Section 3. palmar flexion. Section 4. radial abduction. Section 5. ulnar abduction. Section 6. extension of the thumb.

Isometric contractions: 7. Initial position without loading. 8. 1 kp pulling in dorsal direction. 9. 1 kp pulling in palmar direction.

ulnar notch on the radius has a typical dorsal-radial excavation with uneven edges, apparently caused by attrition from the transformed and dislocated head of the ulna (Figs. 27 and 28).

The roentgenological changes were typical and more or less the same in all the cases of caput ulnae syndrome with rupture of extensor tendons.

Electromyographic study

The pattern of innervation for the muscles passing the wrist during basic movements of this articulation, was first studied in a consecutive series of 11 patients with in most cases a long history of rheumatoid arthritis in order to investigate whether there was any change in the pattern of innervation in such cases.

The findings in this study led to increased interest in the activity in extensor carpi ulnaris. This was studied in a further sixteen cases with the caput ulnae syndrome, of which nine had tendon rupture.

The technique was the same as that used in the examination of healthy patients (see p. 11–12).

In every case there was considerably reduced active palmar flexion at the wrist—sometimes no more than 30° —but the movements during the examination never elicited pain from the radiocarpal joint, so that the recordings could all be accepted. Coaxial needle electrodes were used, as a rule with simultaneous recording from two muscles. The repeated recordings were made during isotonic contraction sometimes combined with isometric contraction.

TABLE 8. *M. extensor carpi ulnaris*.

- + indicates that definite action potentials were recorded in each test.
 (+) indicates that action potentials, often less distinct, were recorded in a few tests.
 - indicates that no potentials at all were recorded in the muscle.

Subjects ^a	Movements				
	Dorsi-flexion	Palmar flexion	Ulnar abduction	Radial abduction	Extension of thumb
E.H.	+	-	+	-	+
O.R.	+	-	+	(+)	+
M.B.	+	-	+	+	
G.A.	+	-	+	-	+
C.F.	+	-	+	-	+
F.A.	+	-	+	(+)	
C.A.	+	-	+	-	+
V.J.	+	-	+	-	+
B.F.	+	-	(+)	-	+
K.G.	+	-	+	-	+
D.H.	+	-	+	-	+
N.K.	+	-	+	(+)	
G.E.	+	-	+	-	
S.J.	+	+	-	-	
E.B.	+	-	+	-	
A.J.	-	-	+	-	
B.F.	(+)	+	+	-	
J.R.	(+)	-	+	-	
22	+	(+)	+	-	+
28	+	-	+	-	+
29	+	-	+	(+)	+
30	+	-	+	-	-
31	+	-	+	-	+
32	+	-	+	(+)	+
33	+	-	+	-	+
34	+	-	+	-	-
37	+	-	+	-	+

^a The numbers refer to subjects with tendon rupture. See Table 9.

Results. Possible changes in the action potentials were not analysed. The pattern of innervation recorded electromyographically in extensor carpi radialis, extensor digitorum communis and flexor carpi radialis et ulnaris resembled that recorded in the healthy subjects. There was a noticeable lack of activity in extensor carpi ulnaris during palmar flexion (see Table 8 and Fig. 29). The activity in extensor carpi ulnaris found during palmar

flexion at the wrist in healthy individuals could be found only in two of the twenty-seven cases with rheumatoid arthritis examined with electromyography. Apart from this, no changes in the pattern of innervation of this muscle were found.

Stereoroentgenographic study

The material comprised sixteen patients with clinical indications of the caput ulnae syndrome, five of them with the complication tendon rupture. Throughout, the same procedure could be used as in the normal material, in spite of the fact that many of these patients had a severe reduction in the range of active rotation movements at the wrist. In all but two cases the pictures, when studied in the stereo viewer, gave a clear indication of the course of the tendon of extensor carpi ulnaris at various degrees of rotation at the wrist. In the two exceptions the contrast medium did not spread satisfactorily and the pictures were difficult to interpret; at surgery the tendon sheath was found to be filled with a mass of synovial tissue, which prevented the contrast medium from spreading to the distal end of the sheath.

In all these cases, which represent varying degrees of the caput ulnae syndrome, the tendon of extensor carpi ulnaris was found to have an abnormal course over the head of the ulna. In the less severe cases the course was practically normal at supination but at pronation at the wrist there was palmar and ulnar dislocation. In the severe cases, i.e. those complicated by tendon rupture, the tendon was completely dislocated from its normal course over the head of the ulna and took a short-cut palmar and ulnar of the dorsally prominent distal end of the ulna (see Figs. 30 and 31).

These investigations confirm the findings at operation for the caput ulnae syndrome, namely that the tendon compartment of extensor carpi ulnaris has disintegrated to such an extent that the tendon is no longer held in its normal course past the head of the ulna.

Discussion

In the healthy wrist the tendon tunnel at the head of the ulna forms a hypomochleum that enables the tendon of extensor carpi ulnaris to contribute to dorsi-flexion and stabilisation at the wrist, especially when the hand is supinated. It has already been pointed out that this muscle plays an important part in stabilizing the dorsal-ulnar region of the wrist.

In patients with rheumatoid arthritis in the wrist there is no activity in

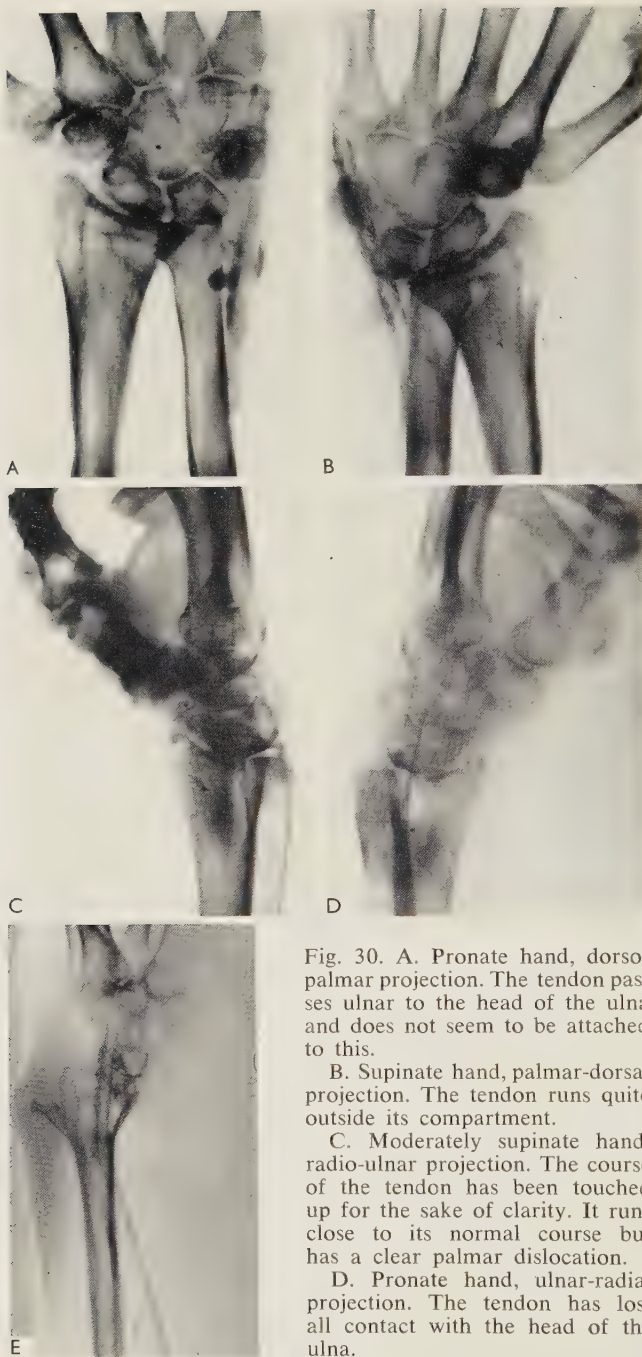


Fig. 30. A. Pronate hand, dorso-palmar projection. The tendon passes ulnar to the head of the ulna and does not seem to be attached to this.

B. Supinate hand, palmar-dorsal projection. The tendon runs quite outside its compartment.

C. Moderately supinate hand, radio-ulnar projection. The course of the tendon has been touched up for the sake of clarity. It runs close to its normal course but has a clear palmar dislocation.

D. Pronate hand, ulnar-radial projection. The tendon has lost all contact with the head of the ulna.

E. Supinate left hand (Case 33), radio-ulnar projection. The tendon is completely dislocated from its normal course. The head of the ulna is deformed and a projecting spicule can be seen.



Fig. 31. Skeleton of the hand with a mock extensor carpi ulnaris attached. The intrinsic ligamentary apparatus has been cut and the tendon compartment of extensor carpi ulnaris opened. These figures indicate the course of the tendon at a) supination and b) pronation of the hand when the compartment for the tendon has been destroyed.

extensor carpi ulnaris during palmar flexion, though other movements are not affected. The muscle is activated in dorsal extension, ulnar abduction and abduction-extension of the thumb. Hence only one of its functions is lost in rheumatoid hands.

Dislocation of the head of the ulna as a result of rupture of above all the intrinsic ligamentary apparatus has been described above. Both at surgery and through the stereoroentgenographic study it has been found that the compartment for the tendon of extensor carpi ulnaris is destroyed at the same time, resulting in palmar displacement of the tendon.

Consequently the tendon, deprived of its hypomochleum, pulls on the carpus from another direction: in certain positions it is no longer in a position to contribute to dorsal extension nor can it act as a stabiliser when the hand is opened to grasp an object.

The function of the wrist is disturbed in other important respects when the tendon of extensor carpi ulnaris becomes dislocated from its tendon

compartment. The destruction of the intrinsic ligamentary apparatus in the course of the rheumatoid disease leaves this tendon as perhaps the most important factor for the maintainance of the distal radio-ulnar joint. When the tendon no longer passes over the head of the ulna, other factors—loading of the hand and arm; the effect of gravity—combine to displace the hand and radius in a palmar direction. Clinically, the displacement of the hand appears as a dorsal dislocation of the head of the ulna, whereas in fact it is just as much a palmar dislocation of the radius and the hand from the ulna, which functions as the fixed axis of the forearm.

The change in the tendon's line of pull, accompanied by the loss of normal activity in the muscle during dorsal stabilisation of the wrist, contribute to the lack of balance between extensors and flexors that is a characteristic of rheumatoid hands. The flexors at the wrist have still less to oppose them and consequently pull the wrist into a position of palmar flexion, where it tends to become fixed.

The same mechanism and course may be observed in the metacarpophalangeal joints in rheumatoid hands: a palmar dislocation of a proximal phalanx often occurs and may gradually become irreducible since the extensor tendon has either ruptured or else slipped from its proper position of function and is no longer able to contribute to the stabilization of the joint.

The few authors who have laid down a programme for the training of muscles in rheumatoid hands all agree that such training should primarily concern the weakened extensors for the wrist and fingers (Powers & Flatt, 1961; Rose & Wallace, 1952; Bendz 1962, personal communication). Yet this training serves no purpose if the muscles in question lack the mechanical possibility of carrying out their normal function.

4. A MATERIAL OPERATED ON FOR THE CAPUT ULNAE SYNDROME COMPLICATED BY TENDON RUPTURE

This investigation is mainly based on cases complicated by tendon rupture. The material comprises thirty-eight cases (twenty-one from Heinola and seventeen from K.S.). All these patients presented clinical symptoms of the syndrome as a sufficient indication for surgery; the ruptured tendons made surgery all the more essential. The patients had a combined total of 116 ruptures of the long extensors to the fingers at the head of the ulna.

Sex and age

The present material comprised twenty-eight women and nine men (one of the men had ruptures in both hands). The average age of the patients with ruptured tendons was 50.2 years at the time of operation. The age range and distribution are given in Fig. 32.

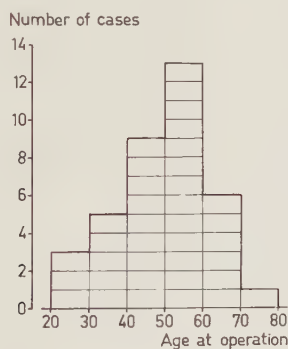


Fig. 32. Age at time of rupture.

Occupation

The distribution of the patients by occupation is given in Table 9. When their ruptures occurred, most of the male patients had long ago been obliged to give up what they regarded as their proper occupation. The painful, insufficient wrist and the reduced function of the hand often contributed to

this, though the contemporaneous and decisive factor was in many cases destructive changes in other joints, in particular those at the hip and knee. Three of the male patients (Cases 1, 11 and 26) were practising their proper occupations unhindered at the time of the follow-up examination.

Of the female patients, nine had employment outside the home. All of them, however, had had daily household work, which in many cases was more exacting for the wrist and hand than an occupation outside the home; this they had performed year after year despite pronounced arthritic symptoms.

Handedness

In materials already published the serious changes in the distal radio-ulnar joint coupled with ruptured tendons have nearly always been located to the right hand, which indicates that attrition is an important factor in the caput ulnae syndrome. In the present material seven cases, all of them with ruptured tendons, had the left hand affected. Of these, however, three patients were definitely left-handed and four used the left and the right hand equally for different tasks, sometimes with the left hand doing the heavier work (see Table 9).

Case histories

All the patients examined had had the diagnosis rheumatoid arthritis confirmed by rheumatologists according to current criteria and had received treatment for their disease at rheumatological clinics, many of them under-

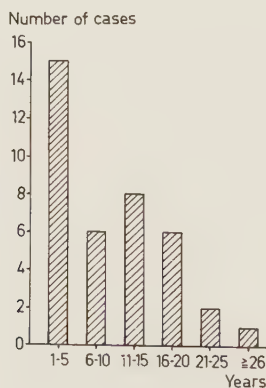


Fig. 33. Interval between the appearance of rheumatoid arthritis in the wrist and tendon rupture. These figures must be regarded as approximate only, as they are based on the patient's own recollection of the time when the disease appeared and when tendon rupture occurred.

TABLE 9. *A material operated on for the caput ulnae syndrome complicated by tendon rupture.*

Sex, age at rupture	Occupation	Handedness	General cortisone therapy	Duration of disease in years at time of rupture from time of first appearance/onset in wrist	Hand affected. Tendon rupture in order of occurrence. (Vp = extens. dig. V. propr.)	Method of tendon repair (in every case synovectomy + resection of the distal end of the ulna was performed)	Observation time (yrs)
m.27	printer's assistant	R	—	14/10	R V _p -V-IV	transfer ext. carp. u.	6
f.25	housewife	R	—	7/7	R V _p -V	side-to-side attachment	5
f.53	housewife	R	—	4/4	R V _p -V-IV	transfer ext. carp. u.	5
f.47	housewife	R + L	+	4/4	R V _p -V	transfer ext. carp. u.	5
f.50	pensioned	R	+	15/15	R V _p -V-IV	transfer ext. carp. u.	5
f.27	dressmaker	L	—	14/14	L V _p -V-IV-III-II	transfer ext. carp. u.	5
f.41	office worker	R	—	14/14	R V _p -V-IV-III	side-to-side attachment	—
f.45	weaving teacher	R	—	22/22	R V _p -V-IV-III	transfer ext. carp. u.	5
f.40	domestic servant	R	—	20/12	R V _p -V-IV	transfer ext. carp. u.	4
m.52	farmer	R	—	23/23	R V _p -V-IV	transfer ext. carp. u.	—
m.55	office worker	R	—	2½/2½	R V _p -V-IV-III	transfer ext. carp. u.	2
f.65	teacher	R	+	12/12	R V _p -V-IV-III	transfer ext. carp. u.	2
m.77	farmer	R	+	2/2	R V _p -V	transfer ext. carp. u.	2
f.51	shopkeeper	R	—	3/3	R V _p -V	transfer ext. carp. u.	1½
f.57	dairyworker	L	—	4/4	L V _p -V-IV	transfer ext. carp. u.	1½
f.45	housewife	R	—	18/18	R V _p -V-IV	side-to-side attachment	1
f.31	dressmaker	R	—	14/10	R V _p -V-IV-III	transfer ext. carp. u.	1
f.51	housewife on a farm	R	—	8/8	R V _p -V-IV	side-to-side attachment (using free graft)	1
f.39	housewife on a farm	R	—	10/2	R V _p -V-IV	transfer ext. carp. u.	½
f.52	housewife	R	—	4/1	R V _p -V-IV	transfer ext. carp. u.	—
f.53	housewife	R	+	5/5	R V _p -V-IV-III	transfer ext. carp. u.	—
m.49	taxi-driver	R	+	17/17	L V _p -V-IV	side-to-side attachment	4
m.49	taxi-driver	R	+	17/16	R V _p -V-IV-III	free tendon graft	4
f.40	post-office clerk	R + L	—	8/3	L V _p -V-IV	side-to-side attachment	4
f.65	housewife	R	+	3/3	R V _p -V-IV	side-to-side attachment	—
m.55	house-painter	R	+	11/11	R V _p -V-IV	side-to-side attachment (using free graft)	4
f.55	housewife	R	+	16/14	R V _p -V-IV	side-to-side attachment	3
f.49	housewife	R	+	16/3	R V _p -V	side-to-side attachment	2½
m.51	builder's labourer	R	—	18/16	R V _p -V-IV	side-to-side attachment	2
f.50	office worker	R	+	27/27	R V _p -V	side-to-side attachment	1
f.60	stenographer	R	+	5/5	R V _p -V-IV	transfer ext. carp. u.	½
f.50	housewife	R	+	4/4	R V _p -V	transfer ext. carp. u.	½
f.68	housewife	R	+	6/6	L V _p -V-IV-III	free tendon graft	½
m.67	office worker	R	+	17/17	R V _p -V-IV-III	transfer ext. carp. u. (using free graft)	1
f.37	housewife	L	—	20/16	L V _p -V	transfer ext. carp. u.	½
f.52	housewife	R + L	—	2/2	R V-IV-III	transfer ext. carp. u.	4/12
m.63	builder's labourer	R + L	—	14/4	L V _p -V-IV	transfer ext. carp. u.	3/12
f.66	housewife	R	—	26/13	R V _p -V-IV	transfer ext. carp. u.	3/12

going several courses. The medical therapy and postoperative treatment, including the physiotherapy, were similar for the Heinola and the K.S. materials. Sixteen patients had received general steroid therapy at different times and in different amounts; four of them were still being treated at the time of the operation (see p. 65).

All the patients supplied information on the development of symptoms in the wrist and the rupturing of the tendons. These accounts are so alike that it will suffice to summarise them in a general description.

After varying intervals from the onset of the disease, movements of the wrist became increasingly painful at the same time as weakness and insufficiency developed, which the patient often ascribed to the pain involved in using the joint.

The rheumatoid arthritis often attacked the wrist from the start. The interval between its appearance in the wrist and tendon rupture is shown in Fig. 33.

Rupture of the extensor tendons to the fingers was painless and often escaped notice at the time. Only two patients reported that the ruptures were associated with a feeling of cramp up the forearm.

In no case has a direct trauma been given as the supposed cause of the ruptures. Some of the patients, however, considered that a contributory factor was unaccustomed burdening of the hand in question.

A former domestic servant (Case 9) had the ruptures occur while she was hospitalized; she connected the ruptures with the movement therapy she was receiving at the time.

A one-time farmer (Case 13), aged 77, trained his fingers by lifting a 5 kilo weight with one finger at a time; he reported that "after a while" he noticed that he could no longer extend the little and ring fingers.

A dairyworker (Case 15), aged 57, stated that the ruptures occurred after she had been cutting thick paper with a pair of scissors.

In all these cases the ruptures were in the hand that usually did the most work. Moreover, in a right-handed housewife (Case 33), aged 68, the tendons to the little, ring and middle fingers of the left hand ruptured in quick succession some weeks after reconstructive surgery had been performed on the right hand.

5. SURGICAL PROCEDURE

PREVIOUS REPORTS

There is general agreement in the literature as to the surgical treatment of painful arthritic changes in the distal radio-ulnar joint. Already in 1915 Darrach described the resection of the distal end of the ulna, which is still used.

In his first report on cases complicated by ruptured tendons, Vaughan-Jackson described the procedure at operation used by himself and, with slight modifications, by all subsequent authors.



Fig. 34. Tendon repair by side-to-side attachment.

A. The synovial bursae have been opened. There was a fresh haemorrhage and rupture of the extensor tendons to dig. V and IV (case 25).

B. The ruptured tendon stumps have been lined up to the intact tendons of extensor communis but have not yet been sutured to these.



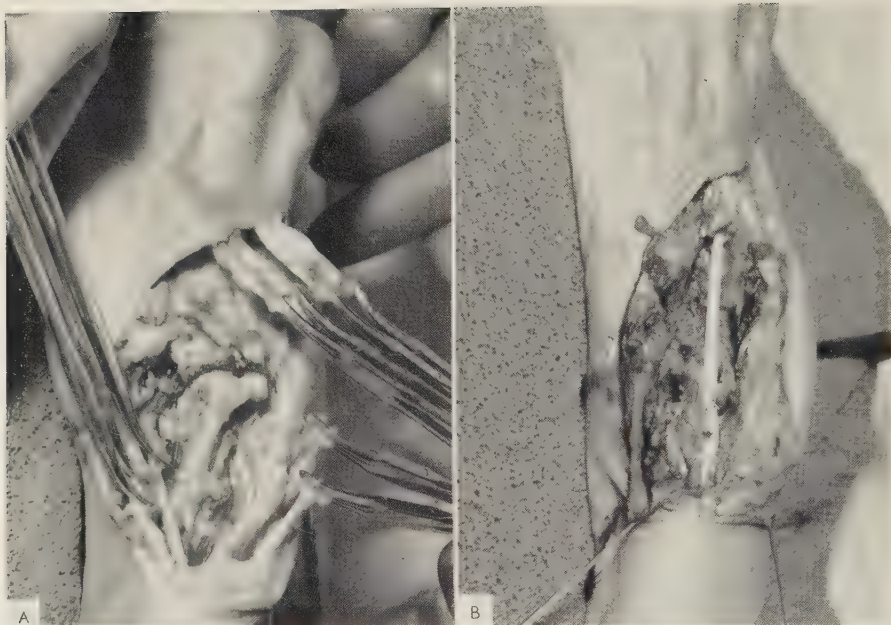
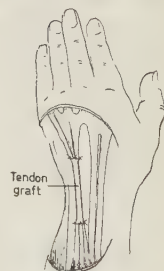


Fig. 35. Tendon graft between the proximal and distal tendon stumps (case 33).

A. Rupture of the extensor tendons for dig. V, IV and III at the dislocated and much-changed head of the ulna.

B. Tendon repair with a free graft taken from the tendon of palmaris longus.



The surgical repair comprises:

1. *Resection of the distal end of the ulna* so as to abolish pain in the distal radio-ulnar joint, increase the mobility there and remove the transformed and dislocated head of the ulna, which has contributed to rupture of the tendons.
2. *Synovectomy*, to arrest the degenerative changes in the structures that are enclosed in synovial tissue and to provide better nutrition and slide for the extensor tendons.
3. *Tendon repair*, to restore the ability of the fingers to stabilize and extend at the metacarpophalangeal joints.

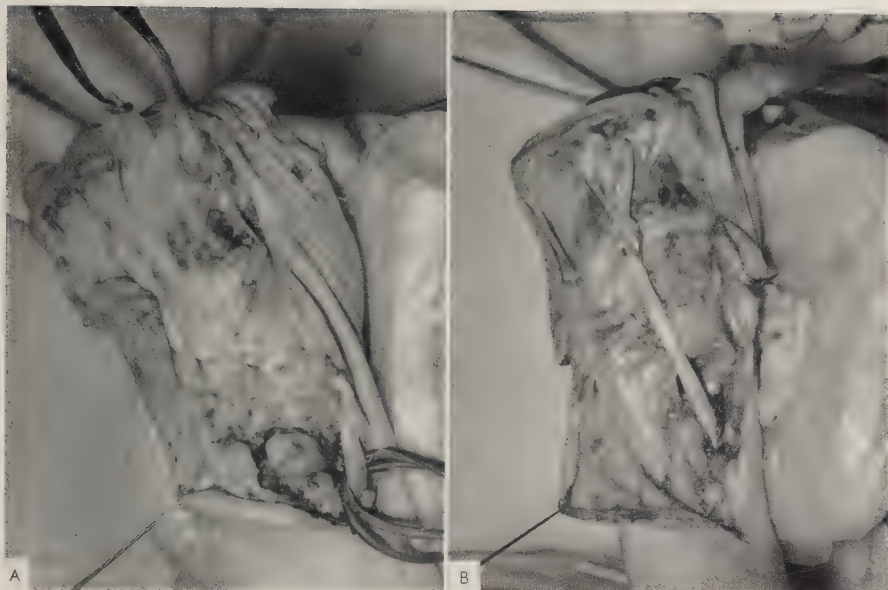


Fig. 36. Transfer of ext. carpi ulnaris to the distal tendon stumps.

A. Before resection of the head of the ulna and tendon repair (Case 34). The tendon of extensor carpi ulnaris (with a loop of rubber round it) has lost all contact with the head of the ulna, which has clearly changed its structure. The tendons to dig. V, IV and III have ruptured.

B. The tendon of ext. carp. ulnaris transferred with the help of a free tendon graft. Note the new course past the end of the ulna.



Although points 1 and 2 appear to have been performed in a uniform manner by earlier authors, their methods for tendon repair may be grouped into three variations, as follows:

- (a) Side-to-side attachment of the distal tendon stumps to nearby intact tendons of extensor communis.
- (b) Free tendon transplants between the proximal and distal tendon stumps.
- (c) Transfer of some other muscle, as a rule extensor carpi ulnaris, to the distal tendon stumps.

All three variations are included in the present material and will be illustrated in greater detail in the following.

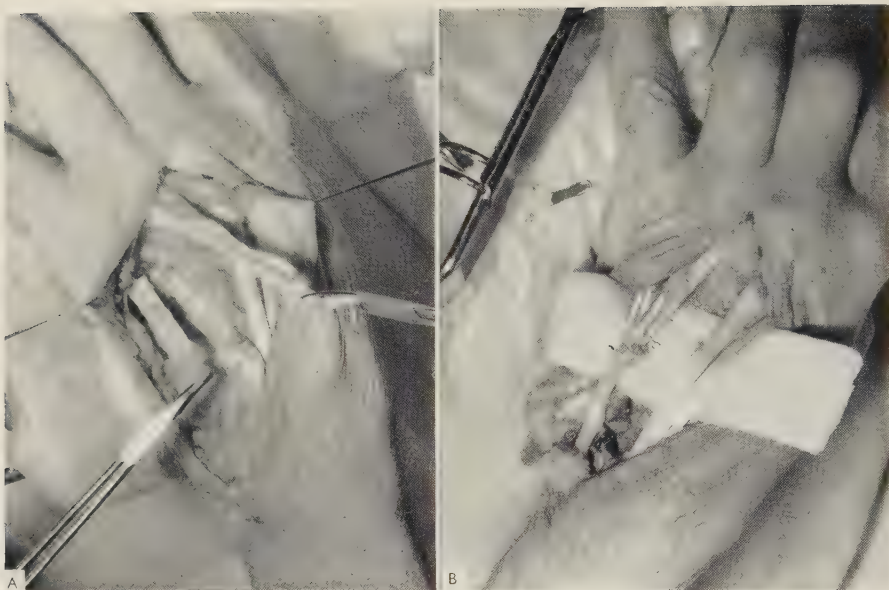


Fig. 37. Transfer of the tendon of extensor carpi ulnaris to the extensor tendons for dig. V and IV (case 37).

A. Rupture of the long extensors to dig. V and IV.

B. Repair by transfer and direct suture of the tendon to the distal stumps.

OWN PROCEDURE

Anaesthesia was achieved in all cases by blocking plexus brachialis. Surgery has been performed in a bloodless field.

A somewhat S-shaped incision has been made in the dorsal aspect of the wrist and hand, permitting a fully exposed operation field. The extensor retinaculum has been severed and, after cleaning up of the affected synovial tissue in the distal radio-ulnar joint, a dorsal synovectomy has been performed along the full extent of the extensor tendons. Between $2\frac{1}{2}$ and 3 cm of the distal end of the ulna has been resected. In the Heinola material six cases and in the K.S. material one case had advanced arthritis in the radiocarpal joint as well. In these an arthrodesis was performed at the same operation, using the resected end of the ulna as a graft.

In six cases in the K.S. material the tendon of extensor carpi ulnaris has been fastened to the new end of the ulna by a pulley, using a free tendon graft from palmaris longus. This graft runs through a hole bored across the distal end of the ulna and then encircles the tendon (see Fig. 38).

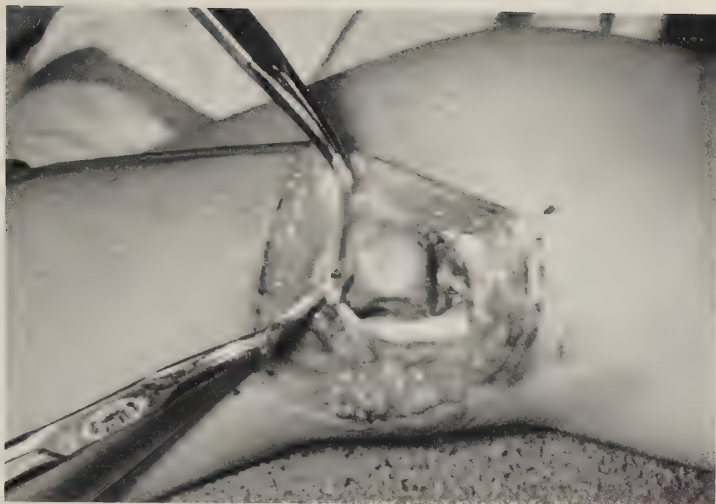
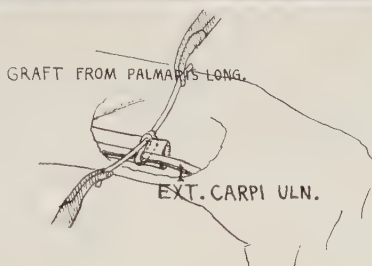


Fig. 38. The tendon of ext. carpi ulnaris restored to its normal course over the distal end of the ulna and fastened to this with a looped tendon graft which runs through a hole bored across the ulna.



The methods used in the various cases for tendon repair are given in Table 9 and in Figs. 34–38.

It will be noticed that in the Heinola material most of the tendon ruptures were repaired by transfer of extensor carpi ulnaris; this method was introduced and described by Vainio (1954).

After suture of the extensor retinaculum and closure of the skin, the hand was fixed in plaster from the forearm to the proximal interphalangeal joints of the affected fingers.

On the first postoperative day, training in movement at the joints in the shoulder, elbow and unaffected fingers was started and after three weeks was extended to include the whole hand.

6. RESULTS OF SURGICAL TREATMENT

PREVIOUS REPORTS

The results so far published of surgery for the caput ulnae syndrome are of a summary nature and deal chiefly with the effects of tendon repair.

For his first two cases Vaughan-Jackson reports that at examination one year after the operation one had full active extension and the other a slight extension defect. In a later report, based on about twenty cases, he comments that "almost any kind of tendon repair can work in this situation", though he adds that side-to-side repair gives inferior results when several tendons have ruptured.

The extension defect reappeared in four cases with tendon repair by direct suture or tendon transfer (Gegan, 1959).

Resection of the distal end of the ulna gave a wrist joint free of pain and with improved rotation in a material of sixteen cases (Pulkki & Vainio, 1962). In this report it was pointed out that the result of the surgical treatment of the tendons is entirely dependent on the status of the metacarpophalangeal joints.

Another report stated that side-to-side attachment results in better function than a free graft, "perhaps because such cases had less total involvement" (Straub, 1962).

OWN RESULTS

It is difficult to estimate accurately the functional results of reconstructive surgery in patients with rheumatoid arthritis. In many patients the activity of the disease is not constant with the result that the mental and physical ability may vary considerably from one examination to another. There is thus at present no reliable method for assessing the functional capacity of rheumatoid hands.¹ The patient's own assessment is therefore of greater significance when judging the results in surgery of rheumatoid hands than in cases where the function of the hand has been impaired for other reasons.

¹ Attempts are in fact being made to overcome these difficulties, by Flatt in the U.S.A. and by Mannerfelt in Sweden (personal communication).

In the present material, moreover, surgery in many cases included resection of the metacarpal heads, arthrodesis in the radio-carpal joint or correction of ulnar deviation of the fingers, or a combination of these. It would, of course, be extremely difficult to isolate the particular results of any one of these measures under the circumstances.

The Heinola material

It has not been possible to follow up the Heinola material in the same way as the K.S. Examinations requiring special equipment were not practicable and, as the patients are spread all over Finland, only a few of them have been examined in person. The results for the others have had to be based on the answers received from the following questionnaire (seventeen received out of twenty-one circularized—two patients deceased).

1. When did your joints start giving you pain?
2. When did you first notice that you could not stretch your finger(s)?
3. Was this after some particularly strenuous activity, accident or other special circumstance?
4. Are you better able to stretch your finger(s) after the operation?
5. Are you still inconvenienced by not being able to stretch your finger(s)?
6. If so, during what activities?
7. Have you received cortisone treatment?

In the form of injections at the joints?

In tablet form?

If so:

What was the dosage?

When did treatment start?

How long did it continue?

Questions 4, 5 and 6 in the questionnaire deal with the patient's assessment of the results of surgery for tendon rupture in conjunction with the caput ulnae syndrome.

Concerning extensor function (question 4), fourteen patients reported an improvement in the ability to extend the fingers. One pointed out that she still found difficulty in putting on her glove (Case 15 in Table 9).

Two patients (Cases 3 and 5 in Table 9) state that they still suffer from a "troublesome" extensor defect in the fingers repaired. One patient (Case 11) writes that his "whole hand is stiff" and that he finds it difficult to extend and flex all the fingers. Two patients (Cases 4 and 12) report an improvement in their ability to extend the fingers but difficulty in fully flexing them.

TABLE 10.

Case	Distal radio-ulnar joint		Active postoperative mobility in metacarpo-phalangeal joints			General usefulness of the hand ^a	
	Painless rotation	Postoperative range of rotation (increase in brackets)				Objective improvement	Subjective improvement
			dig. V	dig. IV	dig. III		
22	×	100 (+ 10)	110°/90	125°/90		+	+
23	×	95 (+ 15)	120°/80	130°/90	145°/90	+	+
24	×	70 (+ 5)	130°/90	145°/110		+	+
25	Deceased						
26	×	40 (+ 0)	115°/80	120°/90		+	+
27	×	70 (+ 10)	110°/100	120°/100		+	+
28	×	125 (+ 30)	145°/90			+	+
29 ^b	(×	60 (+ 0)	145°/90	150°/90		(+)	(+)
30	×	140 (+ 20)	160°/90			+	—
31	×	140 (+ 10)	150°/90	160°/90		+	+
32	×	150 + 0	165°/90			+	+
33	×	150 (+ 40)	130°/90	145°/90	150°/90	+	+
34	×	130 (+ 30)	130°/80	145°/90	150°/90	+	+
35	×	150 (+ 0)	110°/110	(secondary rupture)		—	—
36							
37							
38							

^a + = definite improvement. (+) = doubtful improvement. — = no improvement.

^b Examined during an active phase of the disease.

The K.S. material

The patients operated on at the Karolinska sjukhuset have as a rule lived within a reasonable distance of the hospital and have thus been available for one, and in some cases several follow-up examinations.

The range of rotation of the hand was measured with the patient sitting with the forearm resting on a table at rightangles to the upper arm and with the elbow held into the side of the body.

The angle through which the line that is formed by the dorsal contour of the heads of the metacarpals passed was measured from maximum pronation to maximum supination of the hand, using a protractor fitted with a moveable arm.

Objective assessment of the general usefulness of the hand concentrated chiefly on the opening function. The examinations—carried out both pre- and postoperatively—comprised simple tests of the patient's ability to grasp a number of everyday objects. The subject grasped and lifted:

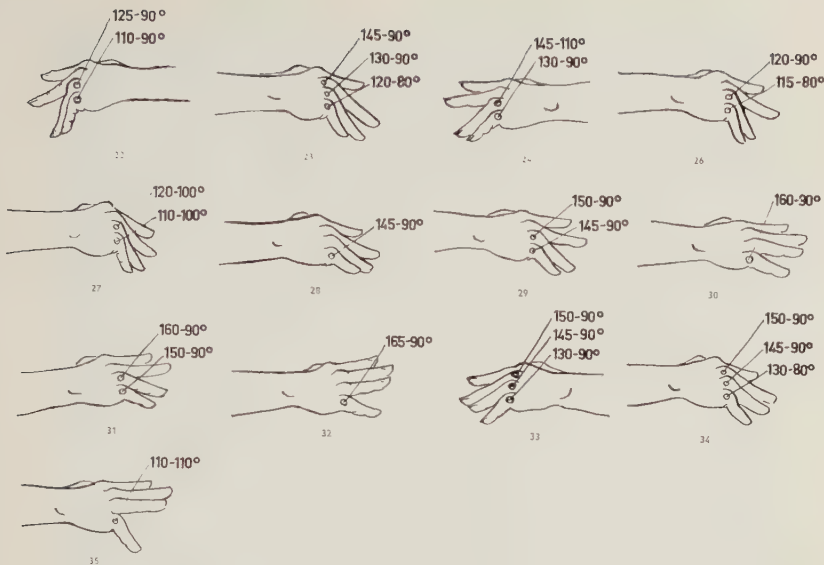


Fig. 39. Drawings of the hands with tendon rupture operated on at K.S. The figures indicate the range of active movement at the metacarpo-phalangeal joints.

- an ordinary tumbler
- a beer bottle (full, $\frac{1}{2}$ pint)
- a tin (diam. 8 cm, weight 300 g)
- a cardboard box containing file cards
- a round ashtray (diam. 11.5 cm)

The patient's ability to manage the task was noted, together with the number of fingers contributing to the grip.

The range of movement at the metacarpo-phalangeal joints was measured with an adjustable protractor.

A number of patients were examined postoperatively with electromyography.

The results for the wrist joints are given in Table 10, together with an objective assessment of and the patient's own opinion on the degree of improvement in hand function as a whole.

The period of observation for the last three patients in the series has been three months or less and hence they have not been included in the numerical results in this table or the next; their own opinion as to whether pain at rotation has diminished has, however, been included.



Fig. 40. The hands of a patient (Case 34) with pronounced caput ulnae syndrome complicated with multiple tendon rupture. The pathological changes found at operation in the right hand are illustrated in Fig. 35, p. 53. The fingers in maximum active extension: (*a*) preoperatively, (*b* and *c*) postoperatively. Note the reduction of the deformity and the improved ability to open the hand.



Fig. 41. The same patient as in Fig. 40 with the fingers in flexion: (a) preoperatively, (b and c) postoperatively.

The results of the tendon repair are shown in schematic drawings (Fig. 39) which depict the hand with the fingers at maximum active extension at the metacarpophalangeal joints. The range of movement at the joints is given for the fingers with repair of the extensor tendons after rupture. The positions of the other fingers at extension are based on measurements and photographs but it is not claimed that these are exact. All these drawings are based on one and the same model without taking into account the considerable variations in the distal joints of the fingers. Nor do they give a clear picture of any improvement in the appearance of the hand. This factor, which may mean a good deal to the individual concerned, is better illustrated in Figs. 40–41.

The size of the material does not permit a comparison between the different methods for tendon repair.

Postoperative complications

One patient (Case 35) noticed about five weeks after the operation that the little finger—which previously could be fully extended—began to drop; after a while it displayed the same extension defect, with inadequate stabilisation, as preoperatively. This patient has not yet been reoperated.

Another patient (Case 7) developed secondary ruptures a few months after a previous operation involving tendon repair but not resection of the head of the ulna. Reoperation comprised renewed tendon repair with resection of the ulna.

In five cases in the K.S. material streaky skin necrosis appeared at the wrist along the line of the incision. Two cases healed spontaneously; in the other three a skin graft was applied to accelerate healing of the skin. In one of these, the necrosis led to adherence between the scar and the repaired tendons beneath. The postoperative and rehabilitation treatment could be carried out according to plan in every case.

Cortisone treatment in the present material

Straub (1962) reports that “it is our impression that there is a distinct relation of finger and wrist joint instability and of tendon rupture to prolonged steroid intake”.

Other authors warn against surgery during cortisone therapy. Its effect on the healing process after tendon repair has been studied, for instance, by Carstam (1953).

TABLE 11.

	Mean interval between onset of disease in wrist-tendon rupture	Mean number of tendons ruptured in each hand
Patients given general cortisone therapy (16 cases)	10.3 years (27-2)	3 (4-2)
Patients treated without cortisone (21 patients representing 22 hands with tendon rupture)	9.5 years (23-2)	3 (4-2)

Two completely separate mechanisms for an injurious effect of general steroid therapy have been described:

- (a) a pathologic effect on the tissues, especially on bone tissue and blood vessels, and
- (b) a general effect that acts on both the mental and the physical state of the patient and at the same time suppresses the pain accompanying movement, with the result that an extra, "uninhibited" attrition at the joints is introduced (Edström, 1942).

In the present material, sixteen cases received varying courses of cortisone treatment and four of these (12, 21, 25 and 32 in Table 9) were receiving steroid therapy at the time of the operation. The duration of the treatment and its date in relation to the time of the operation are shown in Fig. 42.

As can be seen, cortisone therapy was sometimes of extremely short duration and occurred a long time before the operation. The material does not permit assessment of whether tissue changes have been occasioned by the steroid substance as such. It has been reviewed from the following angles:

- (a) Did tendon rupture occur earlier and to a greater extent in the patients receiving cortisone therapy?
- (b) Have the postoperative results been affected by cortisone treatment at the time of the operation and afterwards?

The answers to the first question are given in Table 11.

None of the four patients operated on while they were receiving steroid therapy have had complications in connection with the operation or post-operatively. Nor have any of them shown any sign of inadequate healing of the repaired tendons.

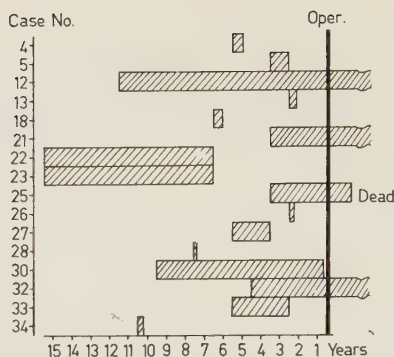


Fig. 42. The duration of general cortisone therapy and its relation to the occurrence of tendon rupture.

POSTOPERATIVE ELECTROMYOGRAPHIC EXAMINATION

The patients examined may be divided into three groups according to the surgical procedure with which they were treated.

Group 1. No tendon rupture; at resection of the head of the ulna a compartment was created for the tendon of extensor carpi ulnaris. (Four patients.)

Group 2. Tendon rupture, repaired by transfer of the tendon of extensor carpi ulnaris (Cases 31, 32, 34 and 38 in Table 9).

Group 3. A control group, with tendon repair by side-to-side attachment in two cases and a free graft connecting the ruptured stumps in the third (26, 29 and 30 in Table 9).

All these patients had been examined electromyographically preoperatively. In one case a weak activity in extensor carpi ulnaris upon palmar flexion

TABLE 13. *M. extensor carpi ulnaris*.

Group 1: Patients with a new "tendon compartment" produced at surgery by using a looped free tendon graft.

Movements	Subjects			
	A.A.	M.B.	B.G.	S.S.
Dorsi-flexion	+	+	+	.
Palmar flexion	+	+	+	.
Ulnar abduction	+	+	+	.
Radial abduction	—	(+)	—	—
Extension of the thumb	+		+	+

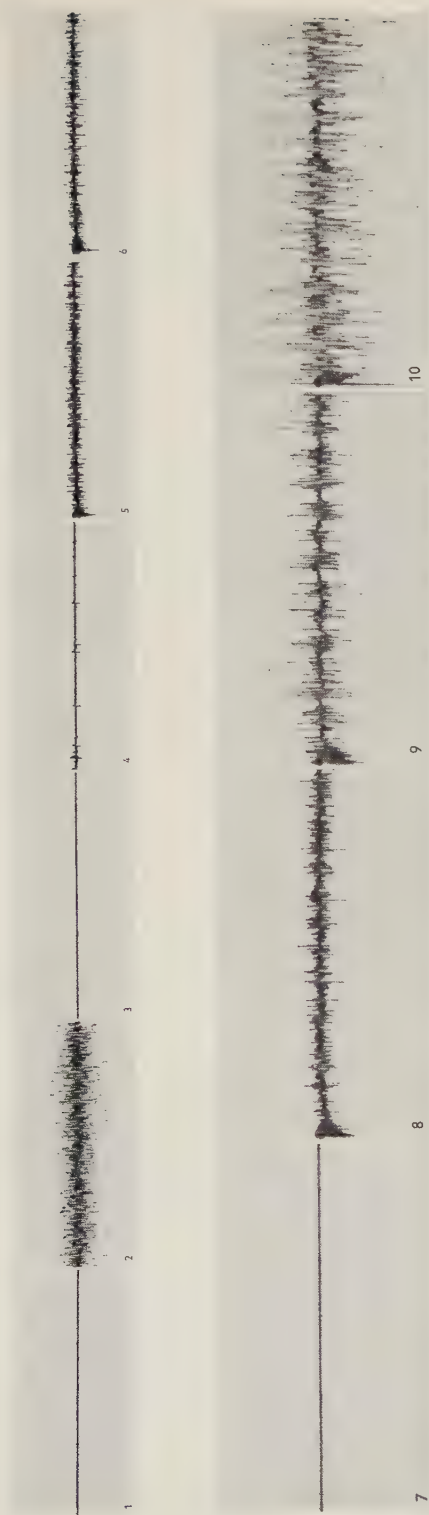


Fig. 43. E.M.G. recordings of the activity in m. extensor carpi ulnaris in a patient in group 2 (case 32 in Table 9).
 Praoperative: 1. initial position. 2. dorsi-flexion. 3. palmar flexion. 4. radial abduction. 5. ulnar abduction. 6. extension of the thumb.
 Postoperative: 7. initial position. 8. dorsi-flexion. 9. palmar flexion. 10. extension of the thumb.

TABLE 14. *M. extensor carpi ulnaris*.

Group 2: Patients in whom tendon rupture has been repaired by transferring the tendon of extensor carpi ulnaris.

Movements	Subjects (numbers refer to Table 9)			
	31	32	34	38
Dorsi-flexion	+	+	+	+
Palmar flexion	+	(+)	+	+
Ulnar abduction	+	+	+	+
Radial abduction	—	(+)	+	—
Extension of the thumb	+	+	+	+

TABLE 15. *M. extensor carpi ulnaris*.

Group 3: Patients with no change at surgery in the course of the tendon of extensor carpi ulnaris.

Movements	Subjects (numbers refer to Table 9)		
	26	29	30
Dorsi-flexion	+	+	+
Palmar flexion	—	—	—
Ulnar abduction	+	+	+
Radial abduction	—	—	—
Extension of the thumb	+	+	+

was recorded preoperatively; no such activity could be recorded in any of the other cases.

The procedure for the examination was the same as that described for the examination of the healthy hands (p. 11–12), except that in some cases recordings were made from one muscle—extensor carpi ulnaris—only.

The results are given in the tables.

Summary and discussion

In the eight cases where the dislocated tendon of extensor carpi ulnaris has been restored at surgery by creating a new tendon compartment or by

transferring it to a course that affords it a better position from which to exert its normal function, the pattern of activity in the muscle has normalised. This indicates that the partial loss of function in this muscle in rheumatoid arthritis is not due to irreversible structural injury to the receptor organs involved.

It would seem instead that some stimulus, necessary for a sufficient afference from certain receptors, has disappeared or altered from the normal pattern of innervation. The tendon, dislocated from the head of the ulna, remains slack during palmar flexion at the wrist (see Fig. 31). If the tendon is restored to something like its normal course, it will become taut and active during palmar flexion. The changes in the normal pattern of innervation therefore appear to be a result of the fact that when the tendon of extensor carpi ulnaris is dislocated in rheumatoid arthritis, the muscle is no longer capable of dorsal stabilization at the wrist. In a control group of three cases where the abnormal course of the tendon was not improved by surgery, the pattern of activity in extensor carpi ulnaris was the same as preoperatively.

7. GENERAL SUMMARY AND CONCLUSIONS

During the last decade there has been a fruitful collaboration in many parts of the world between rheumatologist and hand surgeon, and this will certainly continue to flourish.

Reconstructive surgery in deformed rheumatoid hands may be of considerable value when carried out on certain specific indications, in close cooperation with a rheumatologist and with adequate rehabilitation therapy.

The indications for surgery are sometimes all too clear—severe finger deformities, mechanical obstacles to tendon mobility, tendon rupture, unstable joints, etc.—but sometimes the reasons for the impaired function may be difficult to deduce and evaluate.

Thus we know all too little about the importance of pain as an inhibitor of muscle function in rheumatoid arthritis, nor is it clear what lies behind the imbalance, often considerable, between the “weakened” long extensors and the dominating flexor antagonists.

The present investigation into the abnormal anatomy sometimes found in the distal radio-ulnar joint in rheumatoid arthritis has brought together a number of factors—some of them not reported previously—which contribute to the functional disturbance in the wrist and hand.

The consistent development of a complex of symptoms—here called the *caput ulnae syndrome*—is reported together with the clinical picture and the results of surgical treatment.

The anatomy of the region in question is briefly reviewed, with particular reference to *extensor carpi ulnaris*. The investigation proper is divided into two parts, of which one is an electromyographic study of the distribution of activity in muscles acting on the wrist (previously published together with S. Carlsöö, 1961).

Here, the most important finding as far as the present study is concerned, is that *in palmar flexion at the healthy wrist, extensor carpi ulnaris provides dorsal stabilisation for the region of the wrist joint with the least skeletal and ligamentary support.*

The other part of the investigation has its origins in the findings from the above study and in the observation that, at surgery of rheumatoid hands, the tendon of *extensor carpi ulnaris* is often found to be dislocated from its normal course past the head of the ulna.

A number of healthy subjects were therefore studied with stereoroentgenography after the synovial tendon sheath had been filled with contrast medium, using a special technique and continuous control via a television screen. The course of the tendon was clearly demonstrated from three angles at various degrees of rotation at the wrist.

This study showed that *in healthy subjects there is no lateral displacement of the tendon of extensor carpi ulnaris in its tendon compartment at the head of the ulna in spite of the fact that the line of pull of this tendon varies considerably according to the degree of rotation.*

The term 'caput ulnae syndrome in rheumatoid arthritis' is defined and the reasons for its introduction are given.

The syndrome presents the following clinical picture:

1. Weakness in the wrist and hand, with the opening functions of the hand curtailed.
2. Pain on rotation at the radio-ulnar joint and
3. Reduced range of rotation here.
4. The distal end of the ulna forms a dorsal prominence and can be displaced, with painful crepitations, from its articulation with the radius.
5. The back of the hand and the wrist display bulging synovial bursae corresponding to the tendon sheaths of the long extensors to the fingers and of extensor carpi ulnaris.
6. In some cases, rupture precludes active extension of one or several fingers at the metacarpo-phalangeal joints.

There follows a review of the various symptoms in this syndrome as described by previous authors, chiefly in studies of the clinical picture and history of the tendon ruptures. These reports have been based in some cases on microscopic as well as macroscopic studies and the findings may be summed up as follows.

In rheumatoid arthritis in the distal radio-ulnar joints, the long extensors to the fingers rupture from attrition on the dorsally dislocated head of the ulna; the disease has turned the head of the ulna into a saw-like prominence which cuts through the tendons during rotation at the wrist (Vaughan-Jackson). The factor behind the dislocation of the distal end of the ulna is the destruction of the articular disc (Ehrlich *et al.*). The possibility that the tendons are already degenerating when the ruptures occur is disputed.

My own investigations showed, macroscopically, in all the forty-four hands exposed during surgery, that the intrinsic ligamentary apparatus had been destroyed and that *the tendon compartment for extensor carpi ulnaris had disintegrated, leading to displacement of this tendon.*

In cases with tendon rupture, the tendon stumps showed macroscopic

signs of degeneration. A histologic examination was therefore undertaken, both of these stumps and of adjacent non-ruptured tendons. Resection specimens from the head of the ulna were examined.

An electromyographic study was made preoperatively in twenty-seven cases, using the same technique as in the healthy individuals.

Stereoroentgenographic studies after injection of a contrast medium were made of the course of the tendon of extensor carpi ulnaris in sixteen cases, again using the same technique as in the healthy subjects.

The routine roentgenograms of the distal radio-ulnar joint have also been studied and compared.

These investigations show that:

As previous authors have reported, the intrinsic ligamentary apparatus at the distal radio-ulnar joint is both macroscopically and microscopically completely destroyed. The distal end of the ulna can therefore be dislocated. *The pronounced changes in its skeletal structure give in every case a typical picture on a conventional roentgenogram.*

Microscopic examination of the ruptured tendons shows *degenerative changes unlike those observed in non-rheumatoid subjects.*

The tendon compartment for extensor carpi ulnaris is destroyed. *The tendon no longer passes over the head of the ulna and thus does not contribute to maintainance of the radio-ulnar joint.*

The activity found in healthy subjects in extensor carpi ulnaris during palmar flexion at the wrist is not present in electromyographs from cases where the tendon of this muscle is no longer in a position to contribute to dorsal stabilisation at the wrist.

A follow-up examination was made on patients presenting the caput ulnae syndrome in an advanced form with tendon rupture. These patients constitute a uniform material and they all underwent reconstructive surgery.

The material comprises twenty-one cases treated at Heinola, Finland, and seventeen operated on by myself at Karolinska sjukhuset. In all, there were 116 ruptures of the long extensors to the fingers at the head of the ulna. In the Heinola material the clinical history was studied from the case records and roentgenograms, supplemented by a questionnaire. The surgical procedure was apparent from the reports of the operations and was further explained by the Finnish surgeon during my many visits to Heinola.

The K.S. patients could be examined in person; all of them were operated on by me. They had all been treated at rheumatological clinics prior to the operation, many of them had undergone several courses of treatment and as in the Heinola material all of them were under the care of a rheumatologist at the time of the operation and postoperatively. The medical

therapy was similar in the Heinola and the K.S. materials. Sixteen patients had received general cortisone treatment and four of these were still being treated at the time of the operation.

For the combined materials, the age at which the ruptures occurred averaged 50.2 years, with a variation between two and twenty-seven years from the first appearance of rheumatoid arthritis. Three times as many women had ruptures as men.

In almost every case it is the more active hand that has been attacked. The interval between the appearance of rheumatoid arthritis in the wrist and tendon rupture average a little over ten years in the present material, though it was less than five years in more than half of the cases.

The tendon ruptures occurred without trauma and as a rule without there having been any particular strain on the hand.

A survey of the surgical procedures adopted by previous authors shows these to be similar in many respects though they vary as far as the technique for tendon repair is concerned.

The surgical procedure for the present material is described. It differs from the methods of other authors in that in most cases *the tendon of extensor carpi ulnaris was transferred to the ruptured tendons' stumps while in some cases a new "tendon compartment" was formed for this tendon on the resected end of the ulna.*

The results reported by previous authors are reviewed. The results of treatment in the present study may be summarised as follows:

(a) After the operation all the patients were free of pain due to rotation at the wrist.

(b) Of thirteen cases examined postoperatively in person, 9 had a noticeable increase in active rotation of the hand.

(c) Eleven of the cases examined in person presented an objective as well as a subjective improvement in the function of the hand, in particular in the ability to open the hand and grasp an object.

(d) Twelve of thirteen cases examined postoperatively displayed improved active extension and stabilisation at the metacarpo-phalangeal joints after tendon repair, though the degree of extension varied considerably, depending on the condition of these joints, and in some cases was only slight.

In the present material, *cortisone treatment was not found to have affected the development of the caput ulnae syndrome.* Nor did cortisone treatment at the time of the operation appear to affect the healing of the tendons.

The postoperative electromyographic examination showed *that in eight cases, where no activity could be recorded preoperatively in extensor carpi*

ulnaris during palmar flexion, activity could be demonstrated after the tendon—either through the establishment of a new “tendon compartment” or through its transfer as a motor to the ruptured tendons, with another course past the end of the ulna—had been given a better position from which to contribute to dorsal stabilisation at the wrist.

The caput ulnae syndrome represents a chain-reaction of destructive changes in the distal radio-ulnar joint; these changes impair the function of the hand and wrist and also lead to secondary disturbances outside this region by upsetting the interplay of the muscles.

Fully developed, the syndrome presents a picture that nowadays often leads to reconstructive surgery. The results of such surgery are reported here.

Surgery improves the function of the hand primarily by freeing the patient from pain upon movement at the wrist but it may also result in improved mobility. In cases with tendon rupture, active stabilisation at the metacarpophalangeal joints may be restored as well as active extension, to a varying degree.

Transfer of extensor carpi ulnaris would seem to be the method of choice here since this also gives the muscle a renewed possibility of dorsal stabilisation at the wrist.

In my opinion, however, preventive surgery has an important part to play in the earlier stages of this process, before atrophy or contraction of the musculature sets in together with deformities in the wrist and the metacarpophalangeal joints. A routine clinical examination supplemented with roentgenography will suffice to show what is happening to anyone acquainted with the development of the syndrome.

The results of this study indicate that preventive surgery should comprise an early synovectomy and an early resection of the head of the ulna at the same time as the dislocated tendon of extensor carpi ulnaris should, if possible, be relocated in such a way that this muscle can again contribute to dorsal stabilisation at the wrist.

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